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# LIFE HISTORY STUDIES OF NUTRIA, OR COYPU, IN COASTAL LOUISIANA

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The data here reported include information on food habits and life history obtained in an investigation begun after a review of the literature revealed almost complete lack of published data on the coypu in the wild state in this country. The data, unless otherwise identified, were obtained in Lacassine National Wildlife Refuge, Cameron Parish, in southwestern Louisiana during the period from January, 1946, to April, 1948.

## RANGE

According to Osgood (1943), the coypu, *Myocastor coypus* (Molina), has an extensive natural range in southern South America. It occurs in coastal areas and along the larger rivers from approximately 15° south latitude in southern Brazil, Paraguay, and Bolivia to the Pacific coast in Tierra del Fuego. The subspecies in Louisiana and Texas according to Lowery (1943) is probably *M. c. bonariensis*, a form native to North Argentina, Uruguay, Paraguay, and South Brazil.

The original habitat of the nutria or coypu is in marshes, swamps and along margins of rivers and lakes in fresh-water plant associations. In Louisiana its range is limited to the coastal marshes which may be roughly divided into brackish and fresh-water plant associations. The former are good muskrat marshes while the latter, with the exception of the Terrebonne area, are poor producers of muskrats.

The fresh-water marshes are of two types. The first, producing many muskrats and known as the Terrebonne area, extends eastward from the Atchafalya River almost to the Mississippi River. The other marsh extends westward from the Atchafalya River to the Texas state line. This marsh produces few muskrats and supports populations estimated at 1 pair per 40 acres in the better, to 1 pair per 400 acres in the poorer producing portions. It is in this latter fresh-water ecological niche that the coypu has become most firmly established in Louisiana. In this marsh

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the most common association is composed of saw grass (*Cladium jamaicense*), giant cut-grass (*Zizaniopsis miliacea*), southern bulrush (*Scirpus californicus*) with 15 or 20 per cent a pure stand of maidencane (*Panicum hemitomon*).

### BURROWS, WINTER PLATFORMS AND NESTS

Levees, dikes and ditchbanks are used to some extent for burrows. However, this habit is not so highly developed as in the muskrat. The usual burrow is not extensive or elaborate, consisting of a simple tunnel from seven to nine inches in diameter beginning just above normal water level and extending gradually upward four or five feet to a chamber lined with grass. Usually there is a second entrance sevveral feet above the lower one. It was noted that burrowing and burrow occupancy was limited to the coldest part of the winter. Burrowing activity began when the mean temperature dropped below approximately 40°F. and continued until the mean temperature returned to that point. In the study area this period extended from the first week of December to late February. In areas of dense population adjacent to levees, six active burrows per mile of levee was the maximum number observed. Grazing of levees greatly reduced burrowing activity. Where levees were grazed at a rate of seven to ten acres a head, burrowing activity was reduced by approximately two-thirds. The explanation for this decrease appears to be: (1) Grazing reduces the vegetative cover below the optimum requirement of coypu. (2) Burrows and tunnels often collapse when cattle walk over them and collapsed burrows are deserted.

Winter platforms are built and used during the period that burrows are used. They are not used after the passing of cold weather and soon disintegrate. They are circular, from 20 to 30 inches wide and extend from six to nine inches above the water. These platforms are built in dense stands of cut-grass, saw grass and bulrush where protection is offered from cold winter winds, and are composed of the coarse emergents at hand. The preferred building material in Louisiana is giant cut-grass, although jointed spike-rush, four-square, maidencane and saw grass are also used. A family group uses a platform, the animals lying in close contact to reduce loss of body heat during cold weather.

Nests used by females in bearing litters are made by matting down small areas of dense saw grass or cut-grass. Elaborate nests are not required because the precocious young are born with their eyes open. Nests are also found in dense stands of cattail or other cover if the water depth is only a few inches. However, in deeper water which is favored by coypu, only saw grass and cut-grass will support the weight of a pregnant female.

### FOOD HABITS

Records of specific foods in the original habitat are lacking; they are reported as ordinarily feeding upon aquatic and semiaquatic vegetation, but where they live along the coast they also feed on shellfish (Parry 1939).

Detailed food habit studies were made in an area of approximately 25,000 acres of typical fresh water marsh at the Lacassine National Wildlife Refuge in Cameron Parish and ad-

ditional random check studies were made at several other widely separated locations in coastal Louisiana.

Since stomach and scat contents are too finely divided to allow rapid identification of the foods taken, cuttings and unused portions of foods found at feeding stations were examined. Examinations of the stomach contents of approximately every tenth animal checked for sexual development and pregnancy were made during the 1946–47 trapping season; additional examinations were made during the period July-September, 1947. Scats were collected during the periods March to June and September to November, 1947. The stomachs and scats were examined for evidence of animal foods. No shell fragments, chitinous material or other such evidence were found. These limited data indicate that coypu in the Gulf coast are entirely vegetarian.

Field examinations of plant remains left by feeding coypu revealed that the food is limited to the succulent and soft portions of shoots and tubers. Most of the coarse emergents and a few floating-leaved plants are utilized. They are arranged in descending order of use in Table 1.

Pickerelweed, bull's tongue, cattail, arrowhead, four-square, maidencane, beaked rush and water hyacinth are cut throughout the year and the remaining species (Table 1) during only part of the year. Cuttings on the tubers of white and yellow water lilies are first observed in August and are regular but not frequent until March. Use of giant cut-grass usually begins in late July and that of southern bulrush in late September. These plants are used heavily until the appearance of new growth of bull's tongue and pickerelweed in early April. Cuttings on saw grass begin in late August and continue until mid-April, while utilization of jointed spikerush begins about January 1 and be-

TABLE 1.—FOODS TAKEN BY COYPU IN THE GULF COAST AREA

| Common Name | Scientific name | Period of Use: | | |
|---|---|---|---|---|
| | | All Year | Late Summer to April | Late Winter to April |
| Pickerelweed | *Pontederia lanceolata* | x | | |
| Bull's tongue | *Sagittaria falcata* | x | | |
| Cattail | *Typha spp.* | x | | |
| Arrow head | *Sagittaria graminea* | x | | |
| Squarestem spikerush | *Eleocharis quadrangulata* | x | | |
| Maidencane | *Panicum hemitomon* | x | | |
| Giant cut-grass | *Zizaniopsis mileacea* | | x | |
| Southern bulrush | *Scirpus californicus* | | x | |
| Saw grass | *Cladium jamicense* | | x | |
| Water shield | *Brasenia schreberi* | | | x |
| White waterlily | *Castalia odorata* | | | x |
| Jointed spikerush | *Eleocharis equisetoides* | | | x |
| Spatterdock | *Nymphaea advena* | | | x |
| Water-hyacinth | *Eichornia crassipes* | x | | |
| Beaked rush | *Rynchospora sp.* | x | | |
| Water hyssop | *Bacopa monniera* | x | | |

comes heavier as the more preferred pickerelweed and bull's tongue become less available; cuttings cease in late April when the latter species, arrowhead and water hyssop again are plentiful. Feeding on water shield occurs during the winter when pickerelweed and bull's tongue become scarce. Likewise, the use of cattails becomes much heavier in late December and continues until April.

The author was unable to find published references on foods of wild coypu in this country, but limited information is available for some of the European countries where they have been introduced. Laurie (1946) lists for Great Britain: cattail (*Typha latifolia*), water hemlock (*Cicuta virosa*), reed meadow grass (*Glyceria maxima*) and cabbage, sugar beet, and green vegetables.

Vereshchagin (1941) lists the following as food in South Russia: *Typha angustifolia, Sparganium sp., Phragmites communis, Glyceria aquatica, Carex riparia, Hydrocharis sp., Scirpus lacustris, Scirpus maritimus, Cladium mariscus, Nuphar sp., Nymphaea sp.*, and *Nasturtium officinale.*

Most material cut for food is carried to feeding stations before being consumed. Where available, floating objects capable of supporting an animal, such as large branches, planks or logs are preferred for feeding stations. Shallow or exposed areas are second choice. Elsewhere dense stands of emergent vegetation, usually cut-grass or bulrush, are matted down for support. The function of the feeding station is apparently to allow free use of the forepaws to hold and manipulate the food. A feeding station is very conspicuous, containing uneaten plant debris over an area from 12 to 24 inches in diameter. Feeding stations provide a good index of population density. They show up very well from the air.

There is some seasonal variance in the use of feeding stations. The greatest use occurs during cold weather and the least use in warm weather. The cause of this seasonal change in behavior was not determined, but it may be related to winter platform-building activity.

## REPRODUCTION

No data were obtained on the gestation period of coypu during these studies, but according to Cabrera and Yepes (1940), the period of the coypu is from 127 to 132 days in the natural range. This period was also noted in some animals bred in captivity in France and Great Britain. Williams (1934) and Carrill-Worsley (1935) report 120 days for Great Britain, and there is good evidence that the average is between 120 and 127 days. Carrill-Worsley obtained three litters within one year from one female. Dozier, in correspondence, stated that the gestation period was from 130 to 134 days in animals bred at the Fur Animal Experimental Station in Maryland.

Data collected on wild coypu by the author show that breeding occurs during the entire year. This observation, on pen raised animals, has been reported in most of the references cited.

### *Litter Size*

The data on litter size are based on two series of foetus counts from pregnant females taken on the Lacassine National Wildlife Refuge. All adult females examined were pregnant. The

results indicate that all females were bred during the post-parturition heat which occurs 48 hours after the young are born and lasts from two to four days (Asdell, 1946).

The first foetus counts were made on a random series of 35 females trapped from 4,300 acres during the period December 18, 1946 to February 28, 1947. In this series the mean litter size (foetus count) was 5.63 with a minimum of 2 and a maximum of 11. Although it was estimated that only five percent of this area was overutilized,[1] a one per cent (2 out of 199) absorption of foetuses was detected.

The second foetus counts were made on a random series of 26 females during the period August 7, 1947 to January 16, 1948. In the period between counts the area of overutilization had increased to approximately 10 per cent and the second series was collected from this overutilized area. In this series the mean litter size was 4.23 (foetus count), with a minimum of 1 and a maximum of 9. A 3.5 per cent absorption of foetuses (4 out of 110) was detected. According to the *t* test, the difference in the mean number of foetuses in the two series was highly significant.

The ecological trends resulting from an increasing coypu population are revealed by data on stem counts of eight food species occurring in seven study plots established in the area in 1943 when the coypu population density was much less than the carrying capacity, and when no muskrats or other competing species were present. A comparison between stem counts at the beginning and at the end of the first collection period (Table 2), reveals a slight percentage decrease for southern bulrush and saw grass and a marked decrease in water shield. However, the remaining five food species represented in the plots showed marked percentage increases.

Stem counts at the beginning and end of the 1947–48 collecting period revealed decreases in all but one of the palatable

TABLE 2.—PERCENTAGE OF CHANGE IN STUDY PLOTS STEM COUNTS AS COMPARED TO THE ORIGINAL COUNT IN 1943

| Species | Change During 1946–47 Series Collection | | | Change During 1947–48 Series Collection | | |
|---|---|---|---|---|---|---|
| | Per Cent of Orig. Count on: | | Change in Per Cent | Per Cent of Orig. Count on: | | Change in Per Cent |
| | 11/12/46 | 3/1/47 | | 7/25/47 | 3/1/48 | |
| *Brasenia schreberi* | 320 | 170 | −150 | 0 | 0 | 0 |
| *Castalia odorata* | 13 | 128 | + 95 | 240 | 221 | − 9 |
| *Sagittaria falcata* | 11 | 92 | + 81 | 170 | 154 | − 16 |
| *Eleocharis interstincta* | 59 | 89 | + 30 | 119 | 76 | − 43 |
| *Panicum hemitomon* | 16 | 86 | + 70 | 150 | 80 | − 70 |
| *Scirpus californicus* | 42 | 38 | − 4 | 33 | 30 | − 3 |
| *Cladium jamicense* | 80 | 68 | − 12 | 52 | 68 | + 16 |
| *Bacopa monniera* | 38 | 128 | + 90 | 230 | 406 | +176 |

[1] Overutilization refers to vegetative cuttings in excess of the vegetative growth, resulting in a decreased stem count per unit of area.

food species in spite of lower water levels which favored growth of most of them. Between February and August, 1947, water shield disappeared from the study plots although white water-lily persisted, an indication that the former cannot withstand heavy utilization by coypu. One species, *Bacopa monniera*, showed a remarkable increase in stem count during the study. Competition from six species was reduced in 1946–48 period. This favorable situation, coupled with a very low palatability to coypu, caused the increase. This reaction is comparable to the increase in stem counts of forbes and grasses of low palatability on overgrazed range lands.

The data indicate a progressive deterioration of coypu habitat from the end of the first collecting period to the end, or beyond, the second collecting period. That this decrease in available food was responsible for the decrease in the mean number of foetuses in the 1947–48 series is further substantiated by a significant decrease in weight, for the same body length, during the same period. It is recognized that the two series of animals may not be strictly comparable, since they were not collected at exactly the same seasons, but all things considered, the deterioration of the habitat appeared to the writer to be the primary reason for the reduction in litter size.

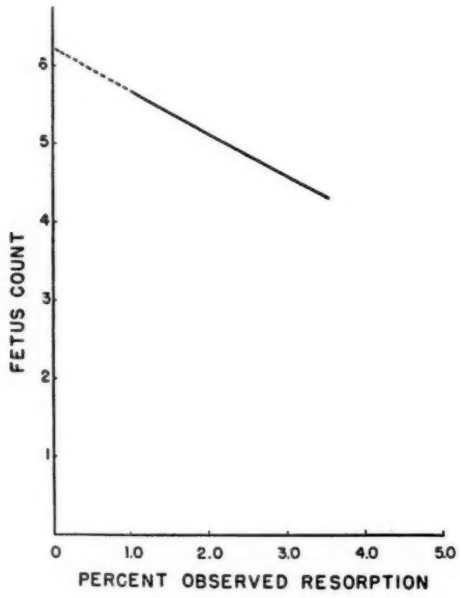


FIG. 1. Fetus count vs. percent resorption.

In a study of the house mouse, Gruneburg (1943) found that litter size depends on the number of eggs liberated at ovulation and the rate of pre-natal mortality. Embryos which perish before implantation in the uterine mucosa are phagocytized completely; their disappearance cannot be demonstrated by inspection of the uterus in later stages of gestation. Embryos dying after implantation, even if they die early and are completely resorbed, leave recognizable constrictions in the uterus.

The foetus count data from these studies show an inverse linear relationship between litter size and rate of prenatal mortality. This relationship is expressed by the formula: $Y = -.55X + 6.2$, where Y is the mean litter size of live births; X is the per cent of observed embryo resorptions; and 6.2 is a constant (the Y intercept of the curve). The curve (Fig. 1) and the formula indicate that the potential maximum mean litter size is slightly greater than 6.0 in the freshwater habitat of coastal Louisiana. There is also the corollary indication that the percent of observed resorption approaches zero as the potential litter size approaches the maximum. The more general conclusion may be drawn that the decrease in

litter size is mainly due to prenatal mortality.

It is evident that diet, and in particular, a food supply below the optimum for maximum litter size plays a dominant role in reducing litter size, by causing an increase in prenatal mortality.

### *Litter Pattern*

Gruneburg (1943) reported that the first litter of the house mouse is decidedly smaller than the second, third, and fourth; thereafter, litter size gradually declines, but variability increases. Observations based on corpora lutea counts (MacDowell, Allen and MacDowell, 1929), show that the place of the litter in the series (parity) is more important than maternal age; in influencing litter size in the house mouse if these two variables are held constant, maternal weight is also correlated with litter size, although the relation is not linear.

The coypu data reveal that the mean size of the first litter is significantly smaller than that of subsequent litters. Walther (1931) and Federspiel (1942) reported similar results on pen-raised coypu.

Before the coypu foetal count data could be analyzed for the influence of parity and body size it was necessary to arrange the data by maternal age, which with these data means arrangement by parity, since matings occur within two to four days of parturition. It was possible to arrange the data according to parity by referring weight and length to growth curves, since the mean size at puberty was accurately determined in the population; with this as a starting point the data were arranged by successive gestation periods. This method was satisfactory through the fifth litter.

Since physical maturity is reached at the age of 30 months, which is the approximate age of a female at parturition of the sixth litter, the relatively small increase in body size between the fifth and sixth litters, with increasing chance of overlap, results in reduction of accuracy of the method. The data indicate that less than ten per cent survive to bear the sixth litter and the number bearing seven litters is negligible in Louisiana.

With the exception of the first being the smallest, the litter pattern of the coypu was found to exhibit marked differences from the house mouse, the laboratory rat, the vole (*Microtus agrestis*) and the other rodents for which the pattern has been reported (Leslie and Ranson, 1940; Gruneburg, 1943; Asdell, 1946).

The size of Louisiana coypu litters (Fig. 3) increases with body size and age of the female, but decreases from the second to the third and from the fourth to the fifth litters. This pattern is repeated when the 1946–47 series and the 1947–48 series are plotted separately. The 1946–47 data reflect the more normal pattern, before food shortage appreciably affected the diet, and the 1947–48 data reflect distortion resulting from food shortage due to overutilization of the food supply. Detailed studies in reproduction by Asdell (1946), Brambell (1937), Hammond (1941) and others indicate that the small size of the third and fifth litters of the coypu results from a depression in the secretion of a specific hormone stimulating embryo growth. This de-

pression of the endocrine function or diversion of its activity is caused by heavy lactation for the large second and fourth litters, during the period following the post-parturition heat and breeding. The data available for studying the pattern of coypu reproduction indicate that the pattern is fixed for this species and is retained, even though greatly distorted, when food deficiency results in prenatal mortalities. Analysis of variance was applied to the data on which the mean values were obtained to express the litter size according to parity (Fig. 3). It was found that the data had only the variability due to random sampling from a common source. Hence it was concluded that the data used to compute the mean litter size, as determined by parity, were not distorted nor unreliable.

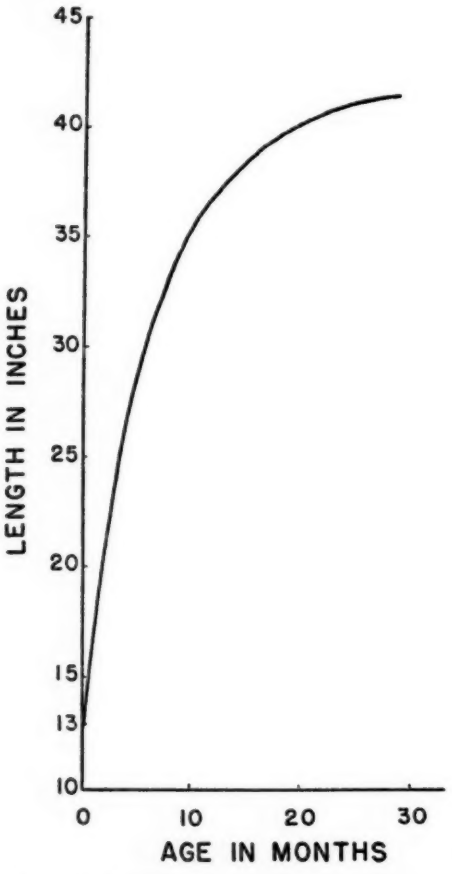


FIG. 2. Coypu length-age growth curve.

Information on the increase in litter size with increase in size of the female was obtained by determining the coefficients of correlation between the mean litter size and body weight and between mean litter size and total length according to the sequence of the litter in the series. In the 1946–47 population, which was considered normal, both of the coefficients of correlation were in very close agreement, i.e., .573 and .570 and both were highly significant. However, since it is obvious that the coefficient of correlation is depressed by the third and fifth litters, which do not increase with parity, the correlation coefficient for those litters which increase with the size of the female was determined for the 1946–47 series and found to be .894, based on weight; the coefficient of determination is .721. This is interpreted to indicate that approximately 72 percent of the increase in litter size between the first and second, third and fourth, and fifth and sixth litters can be explained by the increase in size of a female in good condition.

Similar tests were carried out on the 1947–48 series. Coefficients of correlation of .242 based on length and .073 based on weight were obtained; neither of these approaches the 5 percent level of significance. These tests show that the high degree of correlation existing between increase of litter size and in-

crease in female size in a population in good condition is lost when food deficiency results in prenatal mortalities which distort and would eventually break up the litter pattern if more serious food shortages occurred. Since a value greater than .242 could occur about 50 times per 100 in sampling the data if a zero correlation coefficient existed, it appears that a moderate further decrease would have broken up the litter pattern in the 1947–48 population in the collecting area.

Further important information is revealed by the difference between the correlation coefficients based on length and on weight for the 1947–48 population. As the litter data are the same for each, differences in correlation coefficients are due to changes in weight and length relations as compared to their relations in the 1946–47 data. The very low coefficient based on weight as compared to the coefficient based on length demonstrates the reverse effect, or decrease in correlation coefficient resulting from decreases in weight due to a food deficiency. Here again is evidence of the inseparable relationship between the size of the female (probably better expressed as volume) and the size of the litter. The weight differences between the 1946–47 (normal) series and the 1947–48 series varied from 18 percent at puberty to 7 per cent at maximum length with a difference of 12 percent at the midpoint of the maximum and minimum fecundity lengths. Since the graph of the weight differences within fecundity lengths is a straight line, the mean may be taken as the average. Thus the data indicate a relatively narrow percentage weight range below which the Gulf coast coypu cannot maintain the normal litter pattern. The breeding potential is seriously reduced by the amount of distortion in the 1947–48 pattern (Fig. 3).

The sustained yield carrying capacity of a small portion of the coypu range was exceeded sometime in the winter of 1947. It is of interest to report that a period of nine years elapsed from the time of release or escape of coypu

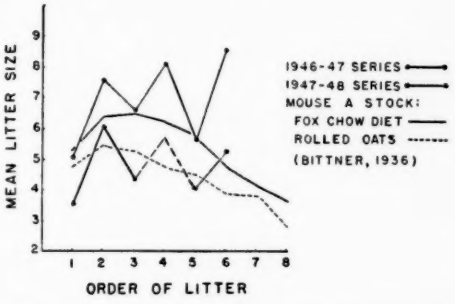


FIG. 3. Variation in litter size due to diet. Original coypu data compared with laboratory mouse. (In 1947–48 curve only one fourth litter observed—indicated by broken line.)

at Avery Island until the sustained carrying capacity was exceeded on 5 to 10 percent of the study area, which was 65 miles from the release point. Space does not permit a discussion of populations, but it may be stated that there is an indication that the cyclic decline which began in the winter of 1947 will eventually occur over the majority of the range in a manner similar to the muskrat decline, although probably not in the same phase.

### *Fecundity*

In Fig. 3 the mean litter size of the 1946–47 and 1947–48 foetal counts are plotted against the order of litters. During the period of approximately

nine months between the first and second series, the area of overutilization increased from approximately 5 to 10 per cent, but all of the females were collected from the overutilized area in the 1947–48 series. The 1946–47 data are taken from 19 females and the 1947–48 data are from 16 females. Although considerable difference seemed apparent by inspection of the plotted data for the two series those used for determining the first litter size in each series were compared statistically. A $t$ value of 2.40 indicates that food deficiency decreases coypu litter size. In addition, the litter pattern was distorted in the 1947–48 series. It is evident that fecundity changes with quantity and quality of food.

There are numerous data in the literature to support the above conclusions. Bittner (1936) demonstrated under controlled conditions with the laboratory mouse that for the first six litters the mean of the litters raised on a commercial "fox chow" was significantly greater than on a diet of rolled oats, powdered milk, meat scraps and salt. In a discussion of the reproduction of the Cricetidae and Muridae Asdell (1946) states: "In species such as these, with an intense rate of metabolism, food supply is probably a major factor in reproduction." Federspiel (1942) reports that inadequate feeding of captive nutria leads to physical degeneration, loss of litters within 48 hours of birth and failure to bear young; adequate diets result in satisfactory litters. Others report similarly for other species.

Both lack of vigor and reduction in numbers of sperm have been produced experimentally by dietary deficiencies of one or more vitamins and especially vitamin E (Mason, 1939). Evans and Bishop (1923) and Mason (*ibid.*) have demonstrated that absorption of embryos results from deficiency in vitamin E. The significant increase in absorption of embryos observed during the 1947–48 period may have been caused in part, if not entirely, by a decrease in the vitamin E intake in the diet as a result of the decrease in available food in the overutilized area.

### *Young at Birth*

The average weight of 16 young at full period in the wild coypu studied in Louisiana was 234 gm. The average body measurements were: body, 180 mm., tail, 130 mm., total length 310 mm. The eyes are open at parturition and the young become very active within a few hours. In captivity, kits have been observed to come out of the nest within a few hours of birth. They have also been observed swimming and feeding on vegetable material within 24 hours after birth. Two kits, weighing 340 gm. and 425 gm. were found 60 feet from the nearest active burrow. The stomachs of both kits were filled with finely divided plant material; their age was estimated, by reference to the growth curve, to be from one to two weeks.

## GROWTH

Maurice (1931) found the average gain to be 400 gm. for the first year and with a slower gain after that. Flower (1931) reports the average age attained by 20 coypu kept in the London Zoo at 4 years and 8 months, and the maximum 5 years and 11 months. Mitchell (1911) reports 2.5 years as the average age of 39 coypu in English zoos. Dozier, in correspondence, states 4.0 years and

21.0 lb. to be maximum age and weight on a small series held at the Fur Animal Experiment Station in Maryland. Federspiel (1941) reported that pen raised stock in Wisconsin attained full growth in two years, with females attaining a weight of 18 pounds at 20 months. Average measurements were given as 24 in. for body and 16 in. for tail. No variation in body measurements between sexes was reported. The male was reported to attain an average weight of 25 lb. at maturity and to have a stronger frame than the female.

These differences between sexes do not exist in the coypu population of coastal Louisiana and east Texas, nor were they indicated by Laurie (1946) for feral coypu in Great Britain. Maximum weights and lengths of the Louisiana coypu are in close agreement with Laurie's data for Great Britain. The measurements of the largest specimens, taken before the deterioration of habitat, were as follows:

| *Sex* | *Total length* | *Body* | *Tail* | *Weight* |
|---|---|---|---|---|
| | in. | in. | in. | lb. |
| Male | 43.0 | 26.0 | 17.0 | 18.0 |
| Female | 41.5 | 25.0 | 16.5 | 17.5 |

The entire population on the study area was markedly thinner during the period August through February 1948 as compared to the period November 1946 through February 1947. During the 1947–48 period the male segment averaged 15 per cent and the females 11 per cent lighter than those observed in the 1946–47 population (Table 3).

TABLE 3.—PERCENTAGE OF WEIGHT DIFFERENCE IN 1947–48 POPULATION AS COMPARED TO 1946–47 POPULATION

| Length in Inches | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| | Weight in Pounds | | Weight Difference | Percentage Difference | Weight in Pounds | | Weight Difference | Percentage Difference |
| | 1946–47 | 1947–48 | | | 1946–47 | 1947–48 | | |
| 15 | .80 | .80 | .0 | .0 | 1.1 | .9 | .2 | 18.2 |
| 17 | 1.25 | 1.05 | .2 | 16.0 | 1.6 | 1.3 | .3 | 18.7 |
| 20 | 2.20 | 1.70 | .5 | 22.7 | 2.3 | 1.8 | .5 | 21.8 |
| 25 | 4.50 | 3.40 | 1.1 | 24.5 | 4.0 | 3.3 | .7 | 17.5 |
| 30 | 7.10 | 5.80 | 1.3 | 18.3 | 6.4 | 5.3 | 1.1 | 17.2 |
| 35 | 10.00 | 8.50 | 1.5 | 15.0 | 9.8 | 8.5 | 1.3 | 13.3 |
| 40 | 15.0 | 12.80 | 2.2 | 14.6 | 14.8 | 13.7 | 1.1 | 7.5 |
| 41 | 16.2 | 14.50 | 1.7 | 10.5 | 16.7 | 15.5 | 1.2 | 7.2 |
| | 57.05 | 48.55 | 8.5 | 15.0 | 56.7 | 50.3 | 6.4 | 11.25 |

Information was obtained on the general weight and growth differences during the two periods by plotting the lengths, recorded to the nearest 0.25 in., against the corresponding weights, determined to the nearest 0.10 lb. Data were plotted separately on fifty-four 1946–47 males, sixty-four 1947–48 males, thirty-two 1946–47 females and sixty-one 1947–48 females. Each series was random, but all weight and length classes were well represented. The resulting curves are shown in fig. 4 for males and fig. 5 for females. A test of symmetry was carried out on the 1946–47 series data since it was somewhat less extensive than the 1947–48 series. A $t$ value of 1.236 compared to 2.576, the 1 per cent or significant level, indicates the data are not skewed and

may be considered to represent the various classes in a symmetrical distribution. A test of significance was carried out on 25 inch-classes between 16 and 41 in. (maximum) on the weight differences between males in the 1946–47 and 1947–48 series. The $t$ value of 11.80 was so large as compared to the 1 per cent probability value of 2.797 that similar tests on weight differences between females in the 1946–47 and 1947–48 series were unnecessary since they are of about the same magnitude. A comparison of these curves reveals that for all lengths greater than 15 in. the weights of the 1947–48 males were from 10 to 25 per cent less than for the corresponding lengths of the 1946–47 males. Differences in weights of females were apparent at all lengths and varied from 7 to 22 per cent (Table 3).

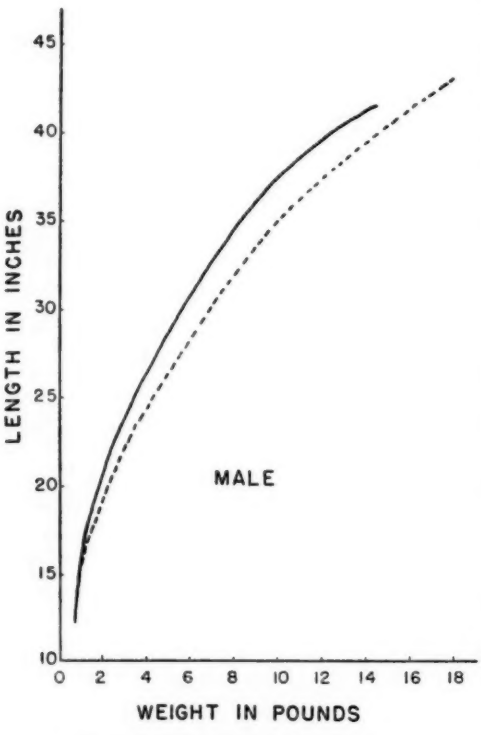


FIG. 4. Length vs. weight curves of 1946–47 and 1947–48 males.

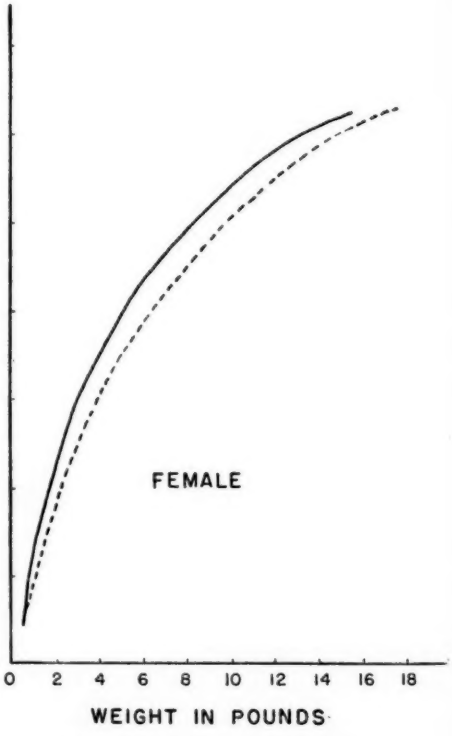


FIG. 5. Length vs. weight curves of 1946–47 and 1947–48 females.

(In each the 1946–47 data are broken line, 1947–48 solid line.)

By expressing the growth differences as increase in weight per inch of growth, the difference is also marked. For example; during the 1947–48 period, in the 15 to 20 in. class, females increased in weight only 73 per cent as fast as during the 1946–47 period and males only 65 per cent as fast; in the 20 to 25 in. class, females increased in weight

only 78 and males only 75 per cent as fast; in the 25 to 30 in. class, females increased in weight only 87 and males only 94 per cent as fast; in the 30 to 35 in. class, females increased only 93 and

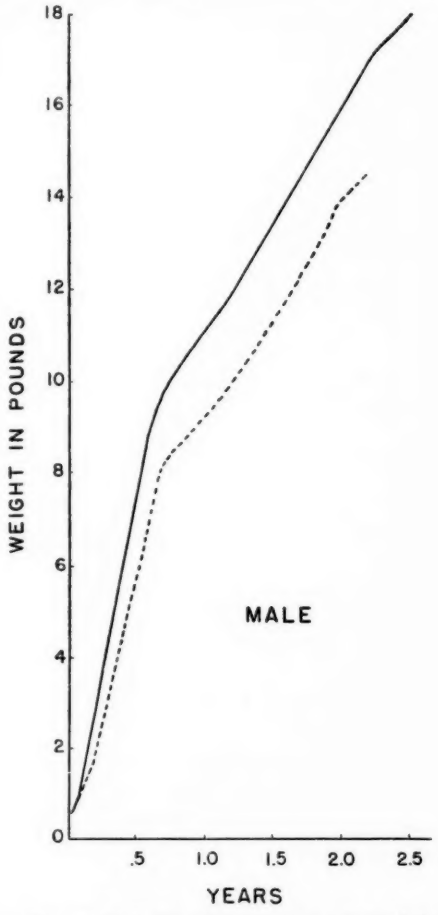


FIG. 6. Male growth curves, age vs. weight. Normal in 1946–47 and abnormal in 1947–48.

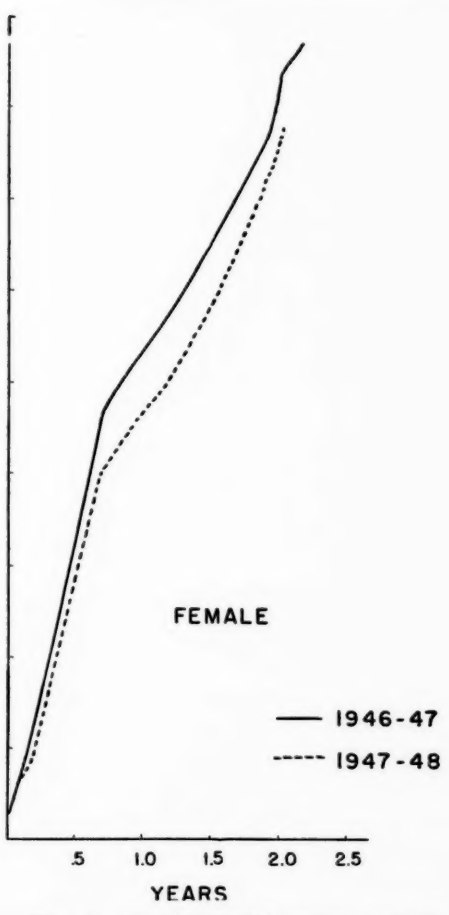


FIG. 7. Female growth curves, age vs. weight. Normal in 1946–47 and abnormal in 1947–48.

males 92 per cent as fast; and between 35 and 40 in., females increased in weight at the same rate as males but at only 86 per cent of the 1946–47 rate. The maximum female weight recorded in the 1947–48 series was only 90 per cent of the 1946–47 weight and the maximum male weight was only 81 per cent of the 1946–47 maximum. As compared to marked weight differences, there was no difference in the maximum length recorded for females; and with males a difference of only 3.2 per cent occurred.

Growth data were obtained from five animals taken during the trapping season which had previously been live-

trapped, tagged and released; data on length at birth, maximum length and age were also available. A length-age growth curve was drawn from the available data (Fig. 2). Since it has been shown there was no significant difference in the rate of growth in the coypu during the two periods compared, it is quite probable that this growth curve is typical of coypu in the Gulf coast marshes of Louisiana and Texas.

By referring to the weight-length growth curves (Figs. 4 and 5), and the length-age growth curve (Fig. 2), it was possible to plot both male and female age-weight growth curves for the 1946–47 and 1947–48 periods (Figs. 6 and 7).

It is concluded from the available data on growth of coypu that: (1) Rate of length-growth is relatively unaffected by food shortage resulting in moderate to semi-severe weight losses. (2) The relatively greater weight differences between males as compared to females, under the same conditions of food shortage, indicates a relatively greater food intake requirement for optimum growth of males. (3) The relatively greater weight loss among both sexes in pre- as compared to post-puberty age groups, and slower weight increases among both sexes in pre- as compared to post-puberty lengths, after the range was overutilized, indicates that the adolescent (20 to 27 in.) age group requires more food on a comparative basis, to maintain normal increase in weight, than sexually mature animals. The length-age growth curve likewise shows a faster length growth during adolescence than for older animals. (4) A corollary on the preceding observation is that starvation losses will occur among the sexually immature age groups before losses occur among the older animals.

That adolescents make up a large segment of the population is shown by 1947 live trapping results in which 40 per cent of 43 trapped in cage traps were adolescents. In the 1946–47 series taken in steel traps, 35 per cent of the 97 examined were adolescents. The slight difference is explained by the practice of trappers to release a few of the small animals at the trapsite because of the low value of small pelts.

### SEXUAL DEVELOPMENT

Sufficient data were obtained to follow the sexual development of the female, but data on males was more difficult to obtain and is not discussed.

Examinations of the reproductive tracts of a series of females ranging in size from immaturity to old age revealed developing Graafian follicles are present in some females when a total length of 21 in. is attained at an age of slightly over two months. Puberty is attained at a mean over-all length of $27.4 \pm 1.8$ in. at an age of from slightly under to slightly over five months. Under favorable food conditions puberty is attained at the shorter length and earlier age; under unfavorable conditions at greater length and age. The smallest female examined which had attained puberty in the 1947–48 series was 29.25 in. over-all. Examination revealed ovulation had just occurred in the right ovary and the right horn of the uterus revealed the changes which accompany the oestrus cycle, but the closed vagina revealed that this female had not yet been bred. This female was

5.1 months of age. The smallest female to attain puberty in the 1946–47 series was 25.5 in. long and 3.8 months of age.

The vagina remains closed until puberty is attained. From a series of 40 pregnant females in which all ages from puberty to old age were represented, it was established that, once opened when puberty is attained, the vagina remains open for the remainder of adult life. This condition occurred without exception for all of the sexually mature females examined. The transition from the closed condition, which continues to the end of adolescence, to the open condition, beginning with the first pregnancy, is portrayed in table 4. The data in this table also indicate that there is no detectable time lag between the time at which puberty is reached and when the first pregnancy occurs.

The data also show that while puberty was attained at a length of $26.4 \pm .9$ in. and an age of $4.1 \pm .4$ months during the 1946–47 period, puberty was not attained until a length of $29.6 \pm .4$ in. was reached at an age of $5.4 \pm .2$ months during the 1947-48 period. By this time a shortage of food, brought about by overutilization, resulted in the average weight of adolescent females being reduced to only 80 per cent of the weight of adolescent females in the 1946–47 population. It is evident that diet plays an important role in sexual development of coypu. In addition to the reduction in size of litters, previously discussed, a deficiency of available food for the 1947–48 population delayed attainment of puberty for approximately 1.3 months beyond the normal age of $4.1 \pm .4$ months.

In a series of 9 feral sub-adult and adult females trapped in Norfolk, Eng-

TABLE 4. SEXUAL DEVELOPMENT AND OPENING OF THE VAGINA

| Length in Inches | Weight in Pounds | Condition of Vagina | Remarks |
|---|---|---|---|
| 19.750 | 1.7 | Closed | Pre-adolescent |
| — | 2.3 | Closed | Pre-adolescent |
| 23.500 | 3.6 | Closed | Developing Graafian follicles |
| 24.375 | 2.7 | Closed | Pre-adolescent |
| 25.375 | 3.7 | Closed | Developing Graafian follicles |
| 26.750 | 4.1 | Closed | Developing Graafian follicles |
| 27.000 | 3.6 | Closed | Developing Graafian follicles |
| 27.000 | 3.8 | Closed | Developing Graafian follicles |
| 28.265 | 4.2 | Closed | Developing Graafian follicles |
| 29.125 | 6.2 | Closed | Developing Graafian follicles |
| 29.250 | 5.4 | Closed | Recent ovulation in right ovary |
| 29.375 | 5.0 | Open | Ovaries show corpora haemorrhagica |
| 30.000 | 5.3 | Closed | Developing Graafian follicles |
| 30.125 | 7.1 | Open | Embryos well along |
| 30.375 | 5.7 | Open | Recent ovulation |
| 30.500 | 6.0 | Open | Ovaries show corpora haemorrhagica |
| 31.125 | 6.2 | Open | Embryos small |
| 32.750 | 7.6 | Open | Pregnant |
| 34.375 | 9.6 | Open | Ovaries show corpora haemorrhagica |
| 36.875 | 10.7 | Open | Pregnant |
| 37.750 | 9.2 | Open | Embryos small |
| 39.875 | 14.9 | Open | Pregnant |
| 40.625 | 13.8 | Open | Pregnant |
| 41.375 | 15.2 | Open | Ovaries show corpora haemorrhagica |

land in 1943 (Laurie 1946) the smallest with corpora lutea and in oestrus was 23.4 in. over-all and weighed 4.125 lb. Two others of slightly larger size were also found with corpora lutea and in oestrus. Maurice (1931) reported that in France fecundity was attained when captive females were about 4 to 5 months old and that females sometimes give birth to their first litter when they are 8 or 9 months old.

## CONCLUSIONS

A wild coypu population in coastal Louisiana was studied during the period January 1946 to April 1948.

The best coypu range is limited to the fresh-water marshes which lie farther inland and adjoin the brackish coastal marshes extending west more than 100 miles from Morgan City to Creole, Louisiana.

The following conclusions have been drawn:

1. Most of the coarse emergent and floating-leaved aquatic plants of the Louisiana fresh-water marshes are used as food by coypu.

2. Winter platforms are built during the same period that burrows are used and have the same function as burrows.

3. In Louisiana coypu showed preference for location of winter platforms and nests in saw grass (*Cladium jamaicense*) and giant cut-grass (*Zizaniopsis mileacea*).

4. The data on reproduction show an inverse linear relationship between mean litter size and rate of embryo absorption.

5. There was a significant increase in absorption of embryos concurrent with the reduction in litter size and decrease in available food.

6. The mean size of litters decreased when overutilization of habitat resulted in a marked reduction in the amount of food available.

7. Additional data on reproduction show that the mean litter size of the first litter is smaller than subsequent litters. The size of coypu litters increases with the body size and age of the female, but with a decrease in size of alternate litters, beginning with the third litter.

8. The series litter pattern of coypu is fixed and is not greatly altered by a moderate change in diet. However, a severe dietary deficiency may result in distorting and finally destroying the pattern.

9. Maximum weights and measurements of wild coypu were found to be 18.0 lb. at 43.0 in. for males and 17.5 lb. at 41.5 in. for females.

10. While maximum length growth is approximately the same, the average maximum weight of wild coypu was only 70 per cent of that of penned animals.

11. No weight differences occurred between sexes in the wild population although in penned stock, mature males are heavier than females.

12. Length growth of coypu is relatively unaffected by food shortage resulting in moderate to semi-severe weight losses.

13. Relatively greater weight losses of males, as compared to females, under the same conditions of food shortage, indicates a greater food intake requirement for optimum growth of males.

14. The larger percent of weight loss and slower increase in weight of the adolescent segment, under conditions of food shortage, as compared to the sexually mature segment of the population, indicates a relatively greater

food requirement by the adolescent segment for normal growth.

15. Starvation losses will occur among sexually immature animals before deaths from starvation occur among sexually mature animals.

16. Puberty was attained at slightly under 4.0 months of age where no food shortage occurred; it was delayed an average of 1.3 months on food-deficient range.

17. In a wild coypu population, food supply is a major factor affecting reproduction, particularly with respect to variation in fecundity and rate of sexual development.

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# A CRITICAL STUDY OF THE RELATION BETWEEN BODY LENGTH AND SEVERAL SCALE MEASUREMENTS IN THE SMALLMOUTH BASS, *MICROPTERUS DOLOMIEU* LACÉPÈDE[1]

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Hoffbauer (1898) working on carp of known age, firmly established the interpretation of scale structure in determining the life histories of fishes. From the original observations of Hoffbauer the modern fishery biologist has expanded his interpretations of the scale structure to include studies on growth rates, influence of fisheries on various age groups, changes in ecological relationships, taxonomy, pollution and parasitology.

One of the most important sources of information obtained from the fish scale has been the use of scale measurements in the back-calculation of body-lengths. A review of the literature concerned with the back-calculation of body lengths in fishes from the scales will show various conclusions as regards the different methods undoubtedly the result of variation between species, choice of formulae, choice of scales, and scale measurements. A recent paper by Schuck (1949) presents a generalized account of the different body-scale relationships and their application in back-calculating body lengths of fishes.

The present investigation is concerned with determining the body-scale relationship and in measuring the relative efficiency of different scale measurements in estimating body length in smallmouth bass. Anterior radius, antero-lateral radius and width of the scale are the measurements compared. The practice of taking "key" scales is also compared with the more customary procedure of taking several scales from a specific area. The relative efficiency of predicting body length from scales taken from the region in which they first arise is compared with those taken in the pectoral region. The statistics of multiple regression have been found useful in making critical quantitative comparisons. Mathematical symbols referred to are those of Snedecor (1946).

## Material and Procedure

For the past several years the division of Fishery Biology at Cornell University has been making extensive studies of the smallmouth bass fishery in Cayuga Lake, New York as reported in a general way by Webster (1947). From the middle of September to the end of October the study is concentrated in a census of the fishermen and

[1] This investigation was conducted in the division of Fishery Biology, Department of Conservation at Cornell University (formerly Laboratory of Limnology and Fisheries, Department of Entomology and Limnology). The author is indebted to Dr. Dwight A. Webster and Dr. Edward C. Raney under whose direction the study was completed. Dr. Webster's constructive criticism of the manuscript was especially helpful.

their catches at a localized area, Flat Rock. It was in conjunction with the 1946 census that the data for this investigation were collected.

Scales were removed from each specimen with tweezers and placed in envelopes with the necessary data recorded. Scales for the University collection are ordinarily removed from the region at the tip of the left pectoral fin. Several scales are taken from each specimen. For the purposes of this study, the University method of taking the scales has arbitrarily been named the standard method and the scales standard scales. Fork lengths of all bass were determined on a measuring board graduated in tenths of inches.

Before removing several scales by the standard method a "key" scale from the pectoral region and the caudal peduncle were taken. The key scale from the pectoral region was taken seven rows down from the lateral line at the tip of the pectoral fin and the key caudal scale taken seven rows down from the posterior base of the dorsal fin. In the beginning of the investigation the pectoral key scale and the caudal key scale were kept separated in small envelopes. Gross differences in the shape of the two scales actually made this unnecessary, however.

All studies of the scales were made from plastic (lumarith cellulose acetate) impressions prepared following the method of Nesbit (1934) using a scale press designed by Lyle M. Thorpe of the Connecticut State Board of Fisheries and Game. The impressions were examined at a magnification of 40 diameters using a Bausch and Lomb micro-projector and measurements were made on the projected images to the nearest millimeter. All measurements originated at the center of the scale focus. The anterior radius was measured along the diameter of the anterior field. The antero-lateral radius was measured from the center of the focus of the scale to the dorsal corner where the anterior field and lateral field of the scale meet. Measurements to an annulus were to the first complete circulus laid down with the resumption of growth.

## RESULTS

*Body and scale relationship.* In determining the relationship between the body length and scale length several scale measurements were plotted against the body length: anterior radius (the measurement most commonly used with ctenoid scales) of the pectoral and caudal scales and the antero-lateral radius of the key pectoral scales (Figures 1–3). These figures are based on the data from 206 bass.

An examination of the figures indicates a curvilinear relationship existing between the body and scale in each case. Each curve is characterized by a prominent inflexion occurring at a body length of approximately 15 cm. The points above this length do not appear to depart seriously, if at all, from a straight-line relation. If regression lines are fitted to the data below 15 cm. and extrapolated they intercept the length axis in each case very close to the observed body length of $2.0 \pm 0.1$ cm. at scale formation (Everhart, 1949). Table 1 presents the data relative to the above regressions of scale length on body length.

*Investigation of curvilinearity.* A study of the scale growth was made in an ef-

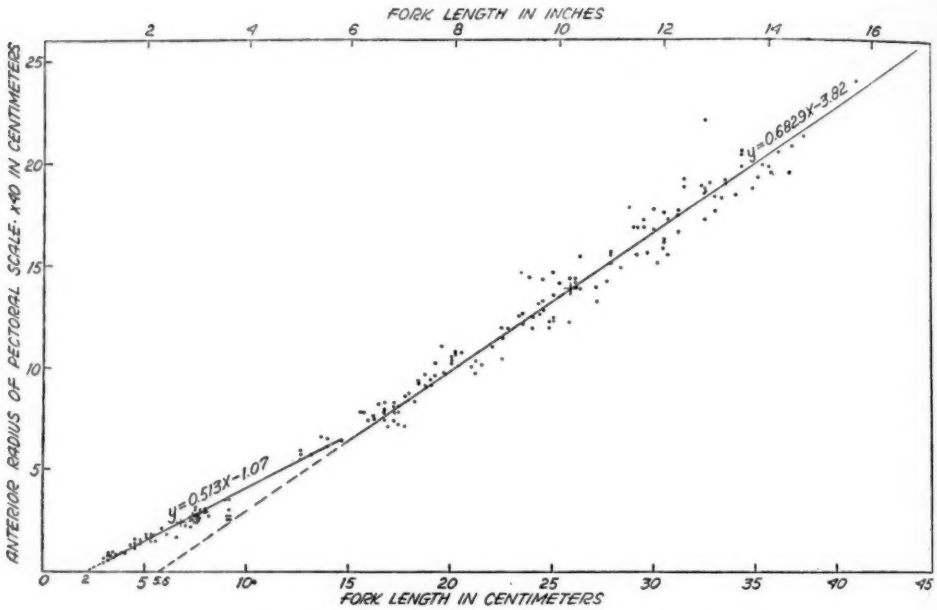


FIG. 1. Relationship between length of smallmouth bass and anterior radius of the key pectoral scale.

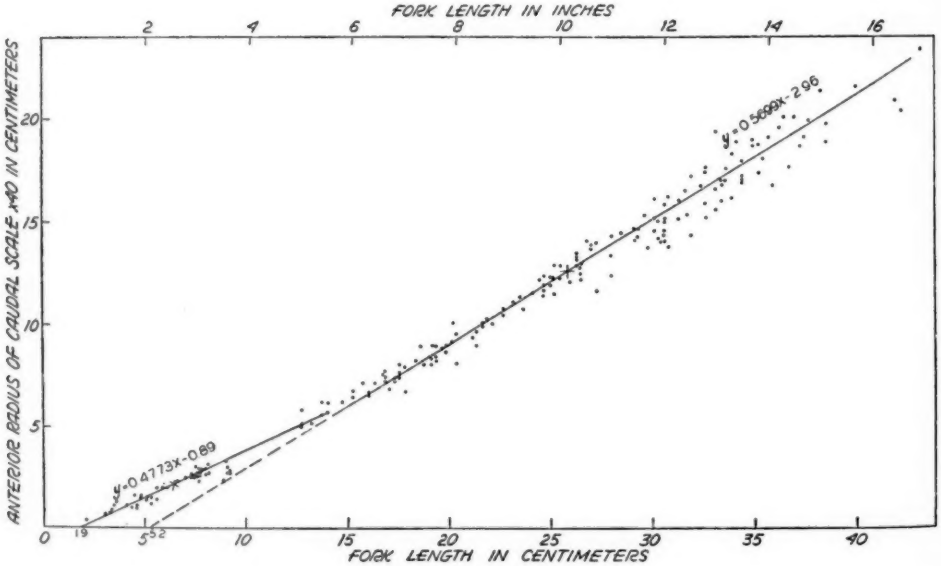


FIG. 2. Relationship between length of smallmouth bass and anterior radius of the caudal scale.

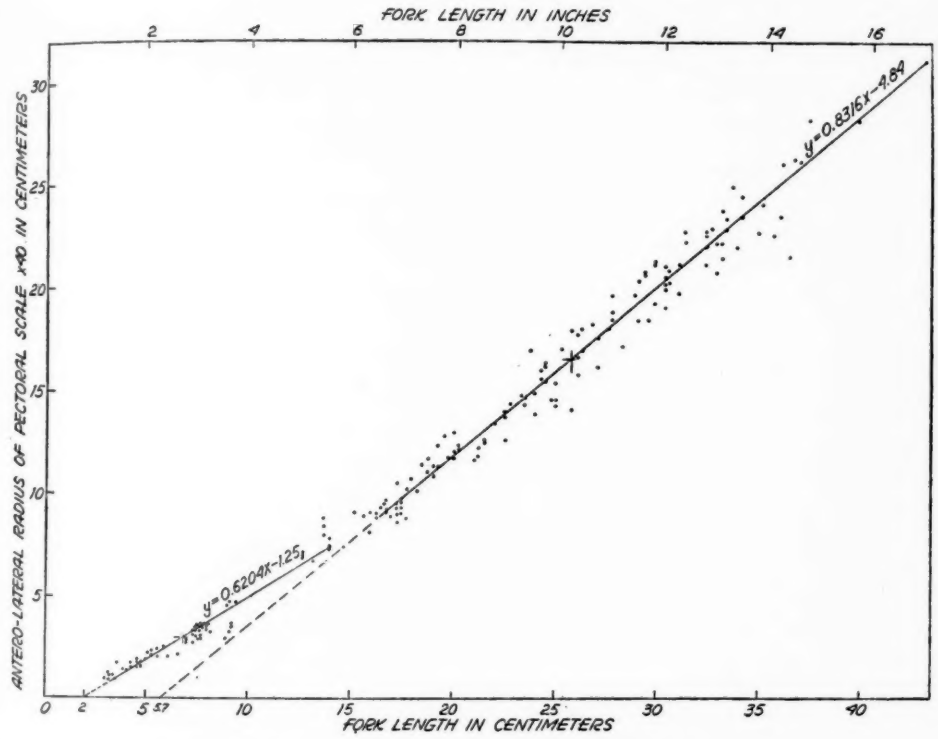


FIG. 3. Relationship between length of smallmouth bass and antero-lateral radius of the key pectoral scale.

TABLE 1.—STATISTICS OF LINEAR REGRESSION OF BODY LENGTH ON THREE SCALE MEASUREMENTS IN SMALLMOUTH BASS FROM CAYUGA LAKE, N. Y.

| Regression | Specimens Below 15 cm. | | | Specimens Above 15 cm. | | |
|---|---|---|---|---|---|---|
| | No. Spec. | Regression Equation | $X$-Intercept ($Y=0$) | No. Spec. | Regression Equation | $X$-Intercept ($Y=0$) |
| Anterior radius of the key pectoral scales on body length | 63 | $Y=0.5130X-1.07$ | 2.1 | 143 | $Y=0.6829X-3.82$ | 5.6 |
| Anterior radius of the caudal scales on body length | 63 | $Y=0.4773X-0.89$ | 1.9 | 143 | $Y=0.5699X-2.96$ | 5.2 |
| Antero-lateral radius of the key pectoral scale on body length | 63 | $Y=0.6204X-1.25$ | 2.0 | 143 | $Y=0.8316X-4.84$ | 5.7 |

fort to determine the factor or factors responsible for the relationship between body growth and scale growth as revealed by Figures 1 to 3. The general procedure was to compare measurements of the scale such as the anterior-posterior diameter, anterior radius, and posterior radius in relation to body length and each other. Finally the ratio of the body length and anterior radius of the key pectoral scale was plotted against the body length for the several age groups.

Workers dealing with species possessing cycloid scales frequently report the diameter of the scales as providing the best estimate of the body length (Van Oosten, 1929). Although the ctenii on the posterior field and the crowding of the circuli preclude accurate measurement in the smallmouth bass scale, the over-all diameter can be

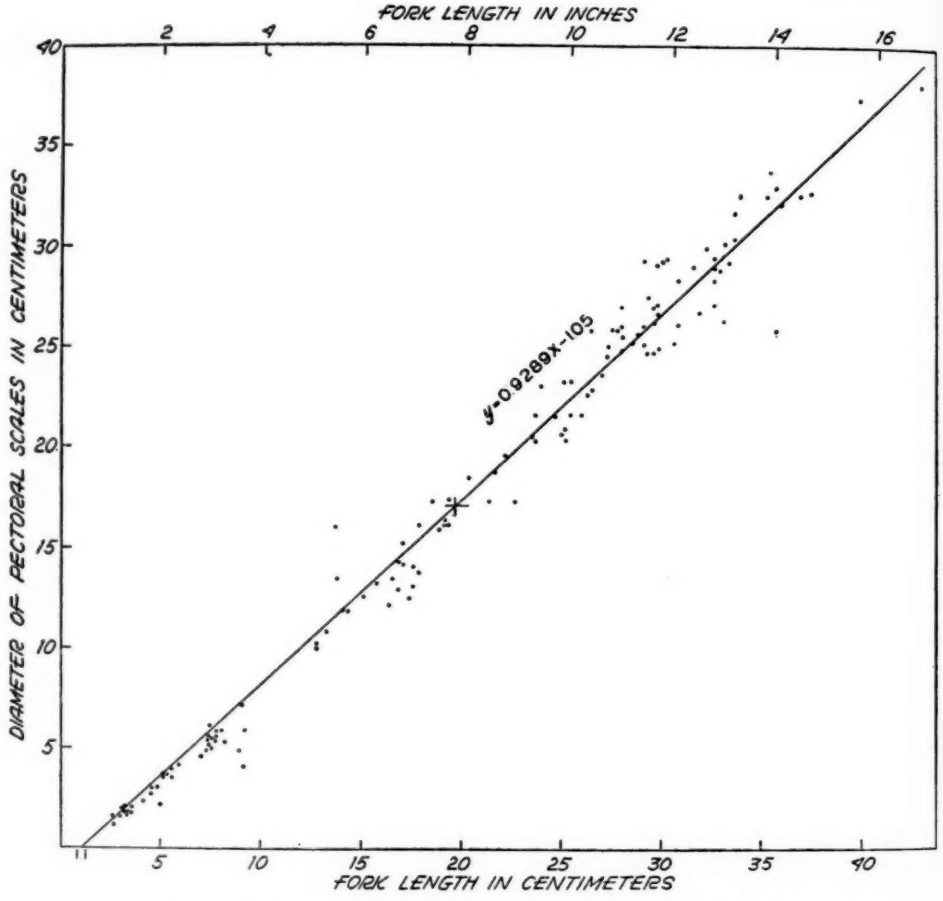


FIG. 4. Relationship between length of smallmouth bass and diameter of the key pectoral scale.

measured. When the anterior-posterior diameters of the key pectoral scales were plotted against the fork lengths, Figure 4, a much closer fit to linearity was obtained over the entire range of the data.

Figure 1 shows that the body length

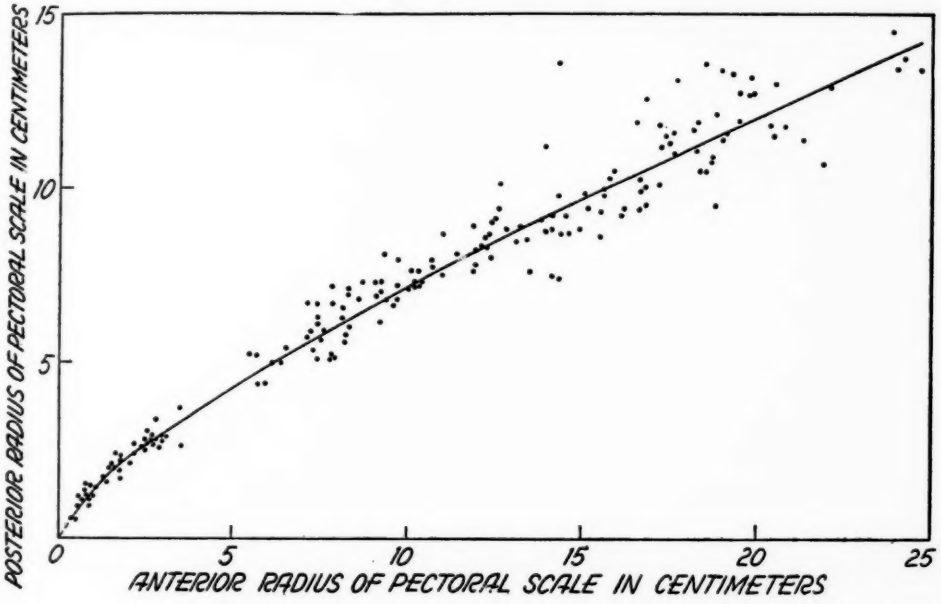


FIG. 5. Relationship between the anterior radius and the posterior radius of the key pectoral scale.

of the younger bass is proportionally greater than the scale length. The curve is swinging upward, however, which indicates that the anterior radius is increasing faster proportionally. After a length of 15 cm. is reached essentially a straight-line relationship exists.

In working with small bass of age group O it was observed that the posterior field of the scale was larger than the anterior field. In older bass, age group I and on, the anterior field is larger. The plotting of the anterior radius and the posterior radius of the key pectoral scale, Figure 5, shows without question the rapid increase in growth of the anterior radius of the scales in smaller bass. The curve was fitted by eye. At a length of 8 cm. the anterior radius (measurements 40X) has caught up with the posterior field and demonstrates a linear relationship. The measurement of the anterior radius of the key pectoral scale is approximately the same at the time it begins to demonstrate a nearly linear relationship with the body length (Fig. 1) and the posterior radius (Fig. 5).

The plotting of the ratio body length/anterior radius of the pectoral scale against the body length is another method of showing relationship of body and scale growth. Van Oosten (1929) used this technique in studying the lake herring, *Leucichthys artedi* (Le-

Sueur). Figure 6 shows the graph obtained when the above ratio was plotted against the body length. The sharp, downward swing indicates the rapid increase in the length of the scale radius. A flattening of the curve is evident after a body length of 15 cm. an opportunity to test the above assumptions. In addition the key pectoral scale and key caudal scale provided an opportunity to compare the relative efficiencies of scales of different sizes taken from the same fish in predicting body lengths. A sample of pectoral and

| | *Pectoral scale* cms. | *Caudal scale* cms. |
|---|---|---|
| Anterior-posterior diameter (40X) | 22.89 ± 3.56 | 20.88 ± 2.50 |
| Dorsal-ventral diameter (40X) | 20.78 ± 3.02 | 16.89 ± 2.16 |

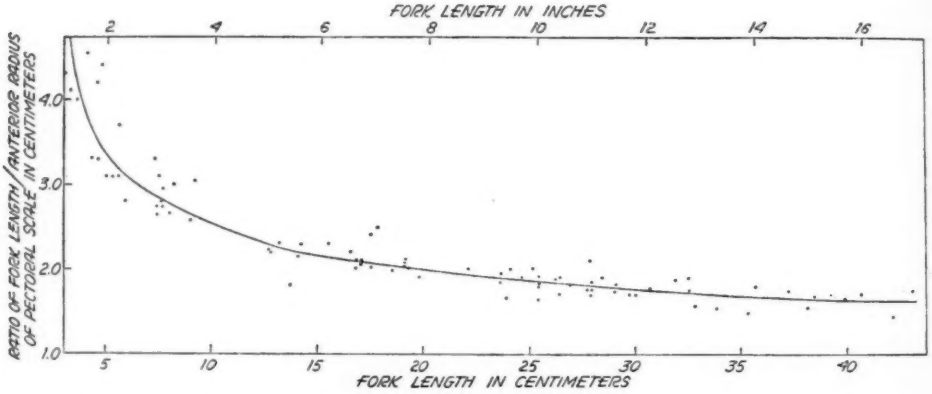


FIG. 6. Relationship between length of smallmouth bass and the ratio of body length/anterior radius of the key pectoral scale.

*Relative efficiency of several scale measurements in predicting body length.* Occasional references in the literature, Parrott (1932) working with brown trout, *Salmo trutta fario* Linnaeus, and Tack (1940) with the minnow, *Phoxinus laevis* Agassiz, conclude that the best scales for age determination and the back-calculation of body lengths are those taken from the region in which the scales first arise. Neither author supplied any supporting quantitative data. Since the scales of the smallmouth bass were observed arising first on the caudal peduncle (Everhart, 1949), taking the caudal scale provided caudal scales from 40 fish was drawn at random from the general body of data available and were used in the comparisons which follow. An idea of the quantitative differences in size provided by scales from these two areas is provided by the measurements shown in Table 2. The caudal scale is significantly smaller (1% level) than the pectoral scale in both measurements.

Advantage has been taken of multiple regression statistics in comparing the relative efficiency of the two scales in predicting body length. The standard partial regression coefficient, hereafter referred to as *b*-prime, provides a means

for judging this. Significance of the differences between the two *b*-primes was tested by "t", as computed from the mean differences/standard error of the *b*-primes. The essential statistics resulting from the several regressions are given in Table 2. The body measurement has been considered the dependent variable, while the two scale measurements are considered the independent variables.

TABLE 2.—MULTIPLE REGRESSION STATISTICS OF SCALE MEASUREMENTS ON BODY LENGTH IN 40 SMALLMOUTH BASS, CAYUGA LAKE, N. Y. SYMBOLS ARE THOSE OF SNEDECOR, 1946. ASTERISKS INDICATE SIGNIFICANCE OF *b*-PRIMES AND THEIR DIFFERENCES

| Variables | | | $r_{1.2}$ | $r_{y1}$ | $r_{y2}$ | $R$ | $b'_{y1.2}$ | $b'_{y2.1}$ | Significance of Difference Between $b'$, i.e., "t" Values |
|---|---|---|---|---|---|---|---|---|---|
| $X_1$ | $X_2$ | $Y$ | | | | | | | |
| Anterior radius of key pectoral scale | Anterior radius of caudal scale | Fork Length | 0.9285 | 0.9687 | 0.9569 | 0.9809 | 0.5813** | 0.4171** | 1.30 |
| Anterior radius of standard pectoral scale | Anterior radius of key pectoral scale | Fork Length | 0.9826 | 0.9884 | 0.9865 | 0.9918 | 0.5520** | 0.4442** | 0.69 |
| Anterior radius of standard pectoral scale | Antero-lateral radius of the standard pectoral scale | Fork Length | 0.9969 | 0.9750 | 0.9742 | 0.9754 | 0.6177** | 0.3584* | 1.31 |
| Anterior radius of key pectoral scale | Width of key pectoral scale | Fork Length | 0.9471 | 0.9757 | 0.9365 | 0.9765 | 0.8621** | 0.1200 | 4.77** |

The *b*-prime values of 0.5813 and 0.4171 computed from measurements of the anterior radii of key pectoral and key caudal scales do not differ significantly. Thus there is no evidence presented which indicates any virtue in taking smallmouth bass scales from the area in which the scales first arise.

Early in the use of the scale method the variation between scales from different regions of the body was recognized. Fishery biologists usually determine the region that apparently gives the most uniform scales, has the least regeneration and is most conveniently located. Many investigators in an effort to further add precision and standardization to their methods have adopted the practice of taking "key" or "X" scales. These scales are chosen from exactly the same position on each fish. As the scales for the studies of the smallmouth bass fishery in Cayuga Lake are always taken at the tip of the pectoral fin, it was possible by taking the key scale, previously defined, in the same region to obtain ideal data with which to compare the two methods and determine whether the additional time and effort to obtain the key scale was justified.

A multiple regression was run on the anterior radii of 40 key pectoral scales and 40 standard scales (random samples) to determine whether or not key scales did, in fact, provide a better estimate of body length. Values of 0.5520 for the *b*-prime of the standard scale and 0.4442 for the key scale are not significantly different, indicating that there is little choice between a key scale and a standard scale. The standard scale would seem a reasonable choice if only because of the inconvenience and time necessary to take the key scale.

Practically all work that has been done with species possessing the ctenoid scales has been done using the anterior radius of the scale. Miller (1946) working with the arctic grayling used the antero-lateral radius in back-calculating body lengths. An examination of the bass scale indicated that this measurement might be employed. The antero-lateral measurement was taken as the greatest distance along the line from the center of the focus to the dorsal corner of the scale where the anterior and lateral fields run together. The multiple regression run on a sample of standard scales of 40 specimens drawn at random yielded *b*-prime values of 0.6177 for the anterior radius and 0.3584 for the antero-lateral radius. The difference between the *b*-primes is again not significant.

The only *b*-primes that were significantly different were those of the anterior radius versus width measurements of the key pectoral scale. When the multiple regression was run on the random sample of 40 scale measurements the *b*-prime for the anterior radius was 0.8621 and for the width 0.1200. This difference is highly significant ($t=4.77$).

From the results of the multiple regressions it may be concluded that there is no evidence to suggest that taking a key scale, or using scales from the area where the scales are first formed gives any added precision to the closeness of the relationship, that is, in predicting previous lengths of Cayuga Lake smallmouth bass. With the antero-lateral radius and width, the relative efficiency is less than with the anterior radius, but significantly so only in the width.

*Agreement of body lengths calculated from the various scale measurements.* Lengths were calculated using Fraser's formula, $L'=C+S'/S(L-C)$ (Fraser, 1916). The correction factor, C, in each instance was the intercept value given in Table 1 for the data of fish above 15 cm. In the interest of brevity the actual mean lengths calculated are not given in this paper, since it is relative agreement in which we are interested at the moment rather than the actual growth. The data referred to are given in manuscript form in tables 13–15 of Everhart (MS).

There were 21 paired comparisons of mean lengths computed from age groups I to VI involving the 1945 to 1940 year classes (six of Age I; five of Age II . . . one at age VI). We may set up the hypothesis that, taking one measurement (anterior radius) as a comparative standard, the other member of the pair will be the same as, greater than, or less than the standard. In unbiased estimates, one would not expect to find any significant departure from an even plus or minus distribution, for example, a 7:7:7 or a 2:17:2 ratio in categories of greater than, equal to, or less than the arbitrary standards in the 21 paired observations.

Following this procedure, we find the following ratios in the calculated lengths using measurements of the same scale or different scales as previously defined:

| *Pectoral vs. Caudal Scales* | | *Standard vs. Key Scales* | | *Anterior Radius vs. Antero-lateral Radius* | |
|---|---|---|---|---|---|
| Pectoral + | 13 | Standard + | 8 | Anterior + | 2 |
| Pectoral = Caudal | 2 | Standard = Key | 6 | Anterior = Ant. lat. | 15 |
| Pectoral − | 6 | Standard − | 7 | Anterior − | 4 |

If we test these observed ratios against an expected 7:7:7, we find Chi-square values of 8.9**, 0.3, and 15.4** are obtained respectively. In other words: (1) Pectoral scales yielded a significantly higher proportion of calculated lengths than did caudal scales from the same fish; (2) There was no bias observed in lengths calculated from standard vs. key scales. (3) The highest proportion of agreement was found between lengths calculated from the anterior radius and antero-lateral radius and there was no bias observed. Perhaps the latter may be due to the fact that the same scale was used for both measurements which reduced between-scale variation.

It is interesting to note that out of the entire 63 comparisons of age group mean body lengths available from the above data only two of the mean lengths proved to be significantly different when subjected to a "t" test. These occurred in body lengths calculated using the anterior radius of the key pectoral and standard scale.

*Agreement between calculated and observed body lengths.* The closeness of agreement of calculated growth with observed growth is of considerable practical interest, but is considered to be outside the province of the present contribution. The empiric growth data of the Flat Rock bass population from 1941 to 1946 were available to the writer in manuscript form (Webster, MS) and certain comparisons were made (Everhart, MS) which will only be mentioned in passing at this time. There was a significant bias in that calculated lengths underestimate the observed lengths in all age groups. The agreement was reasonably good for most practical purposes, but would need adjustment in critical studies. A logarithmic transformation gave poorer agreement than did use of the original values.

## SUMMARY

1. The body-scale length relationship was found to be curvilinear for the measurements tested. The curves were characterized by an inflexion occurring at a body length of 15 cm. Data above 15 cm. do not appear to depart seriously from a straight-line relationship. Regression lines fitted to the data below 15 cm. intercept the length axis very close to the observed body lengths of $2.0 \pm 0.1$ cm. at scale formation.

2. Much of the curvilinearity of the body-scale length relationship is the result of the faster proportional growth of the anterior radius in the scales of the smaller bass.

3. The results of the multiple regression analysis indicate that there is no evidence to suggest that taking a key scale, or using scales from the area where they first arise gives any added precision in predicting previous lengths. The relative efficiency of the antero-lateral radius and width is less than the anterior radius in predicting body lengths, but significantly so only in the width.

4. Body lengths back-calculated using caudal scales are lower than body lengths calculated from the pectoral scales. Lengths calculated from the standard and key scales or from the scale measurements of anterior radius and antero-lateral radius are not biased in either direction.

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# A STUDY OF THE ECONOMIC STATUS OF SANDHILL CRANES IN SASKATCHEWAN[1]

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During the period May 10 to September 18, 1947, the author was employed by the Dominion Wildlife Service to investigate the numbers, distribution, and economic status of the sandhill cranes *Grus canadensis canadensis* and *Grus canadensis tabida* in Saskatchewan. The first part of May was devoted to studying the spring migration. From late May until early August efforts were made to locate breeding populations of sandhill cranes, and during the latter part of the summer consideration of the economic status of cranes received paramount attention.

The problem of distinguishing the greater sandhill crane *G. c. tabida* from the lesser sandhill crane *G. c. canadensis*

[1] The study of the economic status of cranes was carried out under the direction of J. Dewey Soper, then Dominion Wildlife Officer for the Prairie Provinces. Acknowledgement is made of the kind assistance received from many residents of Saskatchewan, notably Fred Bard of the Saskatchewan Provincial Museum and E. L. Paynter and W. A. Hartwell of the Provincial Game Branch.

in the field should be mentioned here. The subspecific differences being wholly relative, it was not felt that such a distinction could be made during periods of migration on any basis other than that of the collected specimen. Consequently, in discussing birds seen during migration periods, reference is made to the species rather than the subspecies.

| *Authority* | *Locality* |
|---|---|
| W. A. Hartwell | Last Mountain Lake |
| R. Fournier | Connell Creek |
| Maurice Street | Nipawin |
| Gustave Yaki | Sandwith |
| J. Miller | Middle Lake |
| D. A. Munro | Big Quill Lake |

With regard to breeding birds, it seems to have been satisfactorily demonstrated by Ridgway and Friedmann (1941) and Bent (1926) that *canadensis* does not breed south of 60° N. latitude. Therefore, it is assumed here that sandhill cranes found breeding or suspected of breeding in Saskatchewan are referable to *tabida*. The subspecific standing of non-breeding summer populations remains in doubt.

## SPRING MIGRATION

The northward migration of sandhill cranes through Saskatchewan is fairly rapid. Residents of the southern part of the Province affirmed that the birds were seen for only two to seven days at any one point during the spring. The heaviest migration seems to proceed in a northwesterly direction, touching the following points: Last Mountain Lake, Quill Lakes, Lake Lenore, Sandwith, Midnight Lake and Meadow Lake. Smaller numbers of migrants are reported to pass through Yorkton, Arborfield and Nipawin. That these are regular flyways is suggested by the fact that migrant sandhill cranes are rarely seen at points such as Foam Lake, Saskatoon and Waskesiu which lie outside the two main routes of passage mentioned above.

The spring migration appears to occur principally between April 15 and May 10. The following are some records of spring occurrence:

| *Date (1947)* | *Numbers* |
|---|---|
| Apr. 28 | Large concentration |
| Apr. 23 | 4 |
| Apr. 27 | Sizable flock |
| Apr. 24 | 5 |
| May 10 | 200 |
| May 12 | 25 |

## SUMMER POPULATIONS

Considerable difficulty was experienced in finding summer populations. Between May 20 and July 30, sandhill cranes were seen in only three localities, although reliable records of recent occurrences in five other areas were reported. No nests were found or young seen. Earlier inspection of probable breeding grounds would likely have yielded better results, since the behaviour pattern of the birds during initial stages of the breeding cycle tends to make them more conspicuous then.

Although, in the absence of any positive data, such as discovery of a nest or observation of young, it is not proper to record a breeding occurrence, the observation of certain behaviour characteristics suggests that the breeding cycle is in operation. When, for example, adults are found singly, or flying low along a rather devious route when flushed, or indulging in a minimum of vocal activity, the designation of probable breeding areas would seem justified. The observation of summer popu-

lations which consisted of small groups of fully grown birds, generally seen together, frequently spending long periods feeding and generally behaving as though unafraid of being observed, was considered an indication of a non-breeding population. It was noted that such populations were more or less transient, and in any event were more mobile than the presumed breeding populations.

During 1947, probable breeding populations are thought to have been located at Cherry Ridge near Nipawin, Montreal Lake, Choiceland, and St. Cyr Lake. Sandhill cranes were observed by the author at Cherry Ridge and Montreal Lake. Choiceland and St. Cyr Lake are recorded on the basis of reports from local inhabitants describing the occurrence and behaviour of cranes.

Five non-breeding sandhill cranes were observed for several days near Paddockwood in late May. These birds were stated to have left that vicinity by the middle of June. Reliable reports of summer occurrences of sandhill cranes which were not believed to be breeding were received from Connell Creek near Arborfield, Smeaton, and Dorintosh.

Most of the Saskatchewan breeding records for greater sandhill cranes are from the prairie and parkland regions. Whether this is principally because more observations were made in those regions during earlier times, or because those regions included preferred habitats is a question for speculation. It is apparent, though, that the modification of environment due to settlement, which has taken place on the prairies and in the parklands, has materially restricted the breeding activities of greater sandhill cranes in those areas. The present breeding range would seem to be confined to the zone of intergradation between the parkland belt and the boreal forest—the area which received most attention during this investigation. The distribution of breeding greater sandhill cranes within the boreal forest is doubtful. It does not seem likely, however, that suitable habitats would be found within the rugged Canadian Shield area, which coincides with much of the boreal forest. The occurrence recorded from Montreal Lake, a point within the boreal forest, might be explained by the fact that there the environment has been altered by the construction of a road creating a good supply of grit and by recent forest fires which have left many open areas. If further investigation should show that breeding greater sandhill cranes are not commonly found in the boreal forest of northern Saskatchewan, it would be reasonable to assume that the prairies and parklands were the centre of the optimum range before the advent of settlement, and that greater sandhill cranes are now attempting to breed in a marginal range in which they are unlikely to be particularly successful. Their lack of success in colonizing the area where they now occur is indicated by their sparse distribution. Greater sandhill cranes were not seen or heard of in many areas which were seemingly as suitable habitats as those in which they did occur.

During the nine weeks which were devoted to seeking breeding sandhill cranes, the following places, among others, were visited: Arborfield, Carrot River, Nipawin, Choiceland, Smeaton, Paddockwood, Emma Lake, Waskesiu, Montreal Lake, Prince Albert, Northside, Henribourg, St. Louis, Shellbrook,

Big River, Green Lake, St. Cyr Lake, Meadow Lake, Dorintosh, Loon Lake, Glaslyn, Sandwith, Cochin and Redberry Lake. At all these points some personal search of likely looking territory was made and local inhabitants were interviewed. At Connell Creek, Cherry Ridge, Montreal Lake, Paddockwood, and St. Cyr Lake intensive searches were made. Because the author was restricted to travel by automobile and on foot, coverage was necessarily incomplete. It seems obvious, however, that the small number of crane occurrences recorded as a result of such coverage indicates that breeding greater sandhill cranes are very scarce in that part of Saskatchewan which was surveyed.

## FALL MIGRATION

The fall migration of sandhill cranes through Saskatchewan is a more dispersed and less continuous movement than the spring migration. Flocks numbering in the thousands may be seen in favourable feeding areas from late August until early October. Although the largest numbers of cranes were seen along the same flyways that are utilized in the spring, data gathered by interview revealed that cranes were sometimes seen in the fall at points where they were never seen during the spring. This further suggests that the movement southward is less well defined in terms of space and time than the northern movement. The following are some records of fall occurrence:

| *Authority* | *Locality* | *Date* | *Number* |
|---|---|---|---|
| Gustave Yaki | Sandwith | Aug. 1, 1946 | 70 |
| Gustave Yaki | Sandwith | Aug. 24, 1947 | 24 |
| Maurice Street | Nipawin | Sept. 16, 1939 | Sizable flock |
| Maurice Street | Nipawin | Oct. 19, 1945 | Sizable flock |
| David Munro | Last Mountain Lake | Aug. 14, 1947 | 75 |
| David Munro | Last Mountain Lake | Sept. 13, 1947 | 3,120 |
| Deane Munro | Prince Albert | Oct. 1, 1947 | 200 |

## OBSERVATIONS AT LAST MOUNTAIN LAKE

The writer studied sandhill cranes at Last Mountain Lake from August 14 until September 14. From August 25 until September 15 J. Dewey Soper took part in the studies. The area most intensively covered during this time was that lying within six miles of the lake shore and extending south for 20 miles from the north end of the lake. During daylight this area was patrolled frequently in an effort to determine distribution of cranes on their feeding grounds, their selection of food, and other factors relevant to the economic problem involved. Other observations were made principally in the immediate vicinity of camps which were established at three different points around the north end of Last Mountain Lake.

Rather definite and regular daily movements of sandhill cranes were noted. During the half hour preceding and the hour following sunrise the birds left their resting areas and flew to the feeding grounds. The resting areas, which included flat grass-covered ground adjacent to alkali beaches and the beaches themselves, were located on the peninsulas and islands at the north end of Last Mountain Lake and on a promontory about eight miles south on the east side of the lake. Feeding took place on fallow land, grain fields and pastures situated on higher ground, generally not further than two miles from the water. On August 15 cranes were first heard calling at 6:30 A.M.

(Mountain Standard Time) and from then until 8 A.M. small groups were continually rising and flying towards the various feeding grounds. From 8 A.M. until 11 A.M. nearly all the sandhill cranes were feeding, no large group of birds being seen around the lake during that time of day. From 11 A.M. to 1:30 P.M. considerable activity took place around the shore-line. Flocks of from 10 to 100 birds were seen returning to the resting grounds around noon and taking off for the fields again in the early afternoon. Selection of resting grounds at noon was not so restricted as in the evening. Cranes were seen at many points along the shoreline, frequently standing, and drinking, in water several inches deep. During the afternoon the majority returned to their feeding grounds. In making this movement they generally flew from the field in which they were feeding to the nearest part of the lake and then flew low over the water or along the shoreline to their resting ground. The greatest number moved during the half hour preceding and the half hour following sunset, although on several occasions cranes were heard calling during flight as late as 11:30 P.M.

While it is not possible to state accurately the number of sandhill cranes that were at Last Mountain Lake at any one time, the order of the number concerned can be ascertained by examining the counts made during observation of evening flights to the resting grounds. These counts, which were made at points lying between favoured feeding grounds and the resting grounds, are thought to represent about 50 per cent of the total population with the exception of the count made at Arlington Beach which probably represented 30 to 40 per cent of the total population. Sample counts follow:

Hagen's Beach: August 14—75; August 16—650

Arlington Beach: August 27—4,000

Imperial Beach: September 13—2,000; September 14—3,120.

Applying the percentages mentioned above, it can be estimated that the total population of cranes at its peak on August 27 was 10,000 to 12,000. It was noted that there was some variation in numbers observed from night to night. Whether or not this indicates a fairly frequent change in population of the area due to some birds leaving and others arriving is uncertain; consequently no estimate of the population transient through the area during the course of the fall migration can be made.

As was mentioned earlier, no attempt was made to distinguish cranes subspecifically in the field. Four specimens collected are, on the basis of bill and tarsus measurements, referable to the subspecies *canadensis*. The general scarcity of *tabida* as a breeding bird in Saskatchewan leads to the assumption that all but a small fraction of the birds seen in migrant companies are *canadensis*. The lack of sexually differentiated characters in sandhill cranes negated the possibility of obtaining any data on sex ratio. The only character by which young of the year can be positively identified is the presence of buff feathers on the forehead, which in adults is a naked red; however, this character was not observed in the field with sufficient frequency to enable the author to calculate a ratio between young and adults

and sub-adults. One of the collected specimens was a young bird of the year.

Considerable attention was given to the determination of the feeding habits of sandhill cranes in the Last Mountain Lake area. During patrols of feeding grounds, 11,673 crane occurrences were recorded in an attempt to ascertain the degrees of preference accorded different types of land. Birds seen in the air were not recorded unless it was obvious from which type of land they had risen.

The study tract consisted of considerable areas of all land types, distributed more or less at random. For instance, a field in fallow, a stand of wheat, and a patch of stubble lay in immediate succession along a two mile stretch of road about three quarters of a mile from the lake. Thus it is felt that the occurrence data given in Table 1 are an actual demonstration of preferences exhibited by cranes rather than a mere reflection of the availability of various feeding ground types.

It is notable that almost 80 per cent of the crane occurrences were on summer fallow, pasture or stubble. These occurrences can hardly have any effect on the economic value of the land concerned. Cranes probably prefer these land types because they offer a feeding area with a view of the surroundings unobscured to standing grain or stooks. A field of stubble is probably preferred to one of swathed grain because of the presence on the former of an ample supply of threshed waste grain.

TABLE 1.—OCCURRENCE OF SANDHILL CRANES ON VARIOUS LAND TYPES

| Land Type | Crane Occurrences | |
|---|---|---|
| | Number | Per Cent |
| Summer fallow & pasture | 1,994 | 17.08 |
| Stubble | 7,304 | 62.57 |
| Standing grain (Wheat—14.28%) (Barley—2.98%) (Other grain—.36%) | | |
| Total standing grain | 2,057 | 17.62 |
| Stooked grain | 195 | 1.67 |
| Swathed grain | 123 | 1.06 |
| All types | 11,716 | 100.00 |

Stomach and crop examinations of four lesser sandhill cranes were made. Results of this examination are presented in Table 2.

Although every kernel of grain was not examined, the item "grain" is considered to be completely referable to wheat. Some counts of insects occurring in the stomachs were made. In the stomach in which grasshoppers con-

TABLE 2.—STOMACH CONTENTS OF FOUR SANDHILL CRANES
Per Cent of Total Wet Volume

| Food Items | Stomach Number | | | | Average |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | |
| Grain | 25.5 | 85.6 | 64.5 | 39.1 | 53.7 |
| Insects | | | | | |
| Grasshoppers | 38.2 | 3.0 | 22.9 | 58.0 | 30.5 |
| Crickets | 6.4 | | | | |
| Ground Beetles | 8.6 | | | | |
| (All insects | | | | | 34.3) |
| Grit | 21.3 | 11.4 | 12.6 | 2.9 | 12.0 |
| | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

stituted 58 per cent of the contents by volume, 40 of these insects were counted: while in the stomach in which grasshoppers constituted 3 per cent of the contents by volume, three were counted. Grit consisted of small, fairly uniform rock fragments, about a dozen of which would replace one cubic centimetre of water. One stomach contained eight well weathered tooth fragments, probably of a dog or coyote, which were presumably picked up as grit.

It is apparent that grain is the major food item of sandhill cranes in this area during the fall, and that wheat is taken most frequently. Of the grain crops, wheat is the commonest in the Last Mountain Lake district. Barley is also eaten frequently, as probably are oats, although there is no evidence of the latter.

## ECONOMIC STATUS

It is obvious that no monetary loss is occasioned by the activities of sandhill cranes on summer fallow, pasture or stubble fields since any grain which may be picked up on such areas is considered by the farmer to be already irrecoverable. Furthermore, some of the injurious insects eaten by cranes are taken from such land types.

Damage occurs when cranes are in standing crops, on swathed crops or on fields of stooked grain—occurrences which were noted to be approximately 20 per cent of the total occurrences. Damage occurs under these circumstances regardless of the nature of the food being taken, since a flock of several hundred cranes hunting grasshoppers in a field of standing wheat would cause almost as much damage by tramping as they would by actually eating the grain. Damage to standing crops occurs to a greater extent in years of poor crops when the stand of grain is thin and below average height. When there is a thick stand of average height, cranes rarely penetrate beyond the margins of the field since visibility and ease of movement are impaired by the dense growth of the stalks. Damage to standing crops was noted in three different fields wherein grain heads had been stripped from the stalks in patches up to 15 feet in diameter. Paths of broken, twisted stalks leading from one feeding patch to another or to the edge of the field were seen. An average loss of 15 per cent of the crop may have been sustained by the owners of these fields.

The occurrence of damage to fields of swathed grain is influenced considerably by weather conditions. If the crop is ripe before the middle of August and harvesting proceeds unimpaired by rainfall it is probable that little swathed grain will be left lying in the fields by the time large numbers of sandhill cranes arrive. However, such a favourable set of circumstances rarely occurs. During 1947, for example, harvesting began early in August, but its termination was delayed for several periods of a week or more because of rainfall. Per unit area, damage to swathed crops is probably more severe than under any other circumstances. When feeding on a swathed crop, cranes walk up and down on top of the swath bending over to nip off heads of grain. Such activity on the part of several birds is sufficient to thresh out a good proportion of the heads which are not actually eaten, and does further harm by depressing the

level of the swath below the point where the pickup of the combination harvester can reach it. Frequently the birds disarrange the swath in order to get at loose kernels which have fallen underneath it. In a 50-acre swathed field, 10 acres were damaged to the extent that economic recovery was impracticable.

No observations of damage by cranes to stooked crops were made, but several complaints of damage of this nature were received.

Although no cases where sandhill crane damage exceeded 20 per cent of the crop value were noted in 1947, reports of damage during 1946 ranged from 10 to 50 per cent of crop value. Losses of even 20 per cent can be very serious for the farmers.

A complete discussion of the efficacy of various methods of controlling the activities of sandhill cranes is out of place here. Generally, it can be said that no one method which was observed in operation seemed to be completely effective. A few farmers found that judicious placing of well-constructed scarecrows was helpful, while others considered such a procedure to be useless. Shooting to scare cranes from the crops appeared to be a good method of control, but it had the disadvantage of utilizing valuable man-hours during harvest time. Many local residents considered shooting a poor policy since it resulted in the cranes being driven from one man's field to another's and consequently tended to disturb human relationships in the neighbourhood. An automatic exploder which was tested during the course of the investigation was completely unsatisfactory.

The agricultural value of lands on which damage by sandhill cranes occurs should be considered in any analysis of the economic status of cranes. Mitchell, Moss, and Clayton (1944) have mapped soils of the Asquith, Biggar and Weyburn associations as well as alkali soils in the northern Last Mountain Lake area. It is notable that the favoured feeding grounds of sandhill cranes lie almost solely within the local limits of soils which are considered mixtures of Asquith fine sandy loam and alkali, and Asquith light loam, Biggar sandy loam, and alkali. Sandhill cranes were rarely seen feeding on soils of the Weyburn association. Mitchell *et al.* state that grain farming, with wheat as the principal crop, can hardly be considered a satisfactory system for Asquith soils, and go on to suggest that the production of certain forage crops such as crested wheat grass and brome grass in association with a program of livestock production would be more advisable. Similar remarks are made with even more emphasis regarding the Biggar soils. Weyburn loams are stated to be better suited to grain production but require careful handling. In a tentative list of comparative ratings and groupings of Saskatchewan soils, which run from excellent soils (76–87) to very poor soils (19–31), Weyburn loam, rated 52, is grouped with the fair soils. Asquith light loam, rated 43, and Asquith fine sandy loam, rated 33, are grouped with the poor soils, and Biggar sandy loam, rated 28, is classed as one of the very poor soils.

Since the greatest concentrations of feeding cranes were found on those soils which were least productive, and were most subject to wind erosion under intensive cultivation, those farmers who

could least well withstand hazards to their crops, and were probably operating on a very small margin of profit, were those who had to contend with the highest intensity of damage. Furthermore, many of the farms in this situation were comparatively small, being only one or two quarter sections in area, and their owners were not in a position in which their losses in one sector could be counterbalanced by good undamaged yields in another. Probably the most satisfactory solution to the problem of crane damage in the area would be to alter the policy of land utilization by the gradual elimination of competitive grain-growing from the poorer lands and the substitution of a community system devoted to the production of forage crops with, perhaps, a few areas devoted to raising grain as a food for the cranes. The preference exhibited by the cranes for the land in question is not at present a result of a superior supply of grain food and therefore would probably remain in effect following such a change in policy, particularly if some grain were available. Such an arrangement would tend to eliminate the pressure of crop damage on individual farmers in surrounding areas, and would be in conformity with a policy of intelligent land utilization for the furtherance of soil conservation. At the same time the application of restrictive measures to a species of striking aesthetic value, one race of which is undeniably scarce, could be kept to a minimum.

## SUMMARY

The breeding range of the greater sandhill crane in Saskatchewan is becoming progressively more restricted and breeding greater sandhill cranes are rare.

During the fall migration large concentrations of cranes, principally lesser sandhill cranes, may occur in agricultural areas in southern Saskatchewan. Almost 80 per cent of 11,716 crane occurrences tabulated were on land in summer fallow, pasture, or stubble.

Damage to standing, stooked or swathed grain crops may be considerable for the individual farmer concerned. The occurrence of such damage is greatest in years of late harvest. Damage to crops of low yield is proportionately greater than to good crops. Most crops damaged were on fair to poor soils.

No one method of control has been found to be completely effective. Alteration of the policy of land utilization, by elimination of grain growing on poor soils where concentrations of cranes occur, would be a desirable long-term solution to the problem of crane damage.

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# SAGEBRUSH AS A WINTER FEED FOR DEER

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## Introduction

Sagebrush (*Artemisia tridentata*) is probably the most important winter deer forage of the intermountain country. It is present on most foothill ranges upon which deer winter. Exceptions occur where fire or cultivation has removed it. Commonly it is mixed with other forage as an understory to juniper or intermixed with plants such as oak, bitterbrush and cliffrose. Whatever the associated plants, deer consume considerable amounts of sagebrush and when, as commonly happens, other more palatable plants are gone it may provide almost the entire sustenance for considerable periods.

Little is known of the feeding value of sagebrush. Chemical composition figures indicate that it may be fairly high in protein (Esplin *et al.* 1937) and possessed of only a moderate amount of crude fiber.

Digestible nutrient values are reported for sagebrush but these are estimated values (Henry and Morrison 1943). No known digestibility figures exist for any of the subspecies of *A. tridentata*. No instance is known of digestion trials with mule deer although whitetailed deer have been the subject of digestion trials (Maynard *et al.* 1935 and Forbes *et al.* 1941).

The subspecies *A. t. typica* (big sage) is the most prevalent form of sagebrush on deer winter range. To learn something of the nutritional value of this subspecies, and of the relative palatability of this compared to the subspecies *A. t. nova* (black sage) the following experiments were conducted.

## Procedure

In March of 1948 six mule deer were placed on diets of two subspecies of sagebrush, *Artemisia tridentata typica* and *A. t. nova*. The forage was collected daily, tied in large bundles, weighed and placed in the deer pens. Each deer was in a separate enclosure. Additional bundles were exposed in a similar manner but were not within reach of the deer. These were to serve as a means of correcting the weight losses of the browsed bundles due to changes in moisture content through drying. Samples of the forage were removed periodically and dried to provide a means of determining dry weight of the material consumed. Care was exercised in

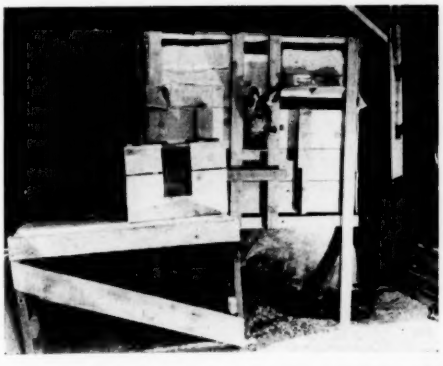

Fig. 1. View of one of the cages used in the experiment with the feed box removed.

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taking this material to secure the same proportion of leaves and stems that the deer have removed in their foraging activities.

At the same time that this procedure was begun two digestion cages were put in readiness and (as soon as possible) two deer were moved into the cages. As soon as data were secured from these, other deer were placed in the cages. Before collections were made for chemical analysis each animal was held in a cage on a diet of *A. t. typica* for a period of about 4 days to get the animal adjusted to the pen, and clear the digestive tract of material other than big sage. Thereafter collections of feces and urine and samples of forage were made daily for a ten day period. The forage consisted of the previous summer's growth of twigs and leaves. The shoots were clipped off by hand and placed in the feed boxes.

The cages were five feet square with floors of heavy steel mesh wire under which were metal pans for delivering urine to bottles. Between the floor and metal tray, finer-mesh screen wire intercepted the feces. The animals could move about freely within the cages.

Of the six deer that were at hand when the trials were begun the first winter it proved possible to complete trials on but four. One animal refused to eat sufficient amounts of the sagebrush to sustain life and was changed to another diet without having been placed in a cage. One animal died in a cage during the progress of the experiment.

TABLE 1.—PERTINENT DATA ON DEER USED IN EXPERIMENT

| Deer No. | Sex | Age as of March '48 | Previous History and Comments |
|---|---|---|---|
| 83 | female | 2½ years | Caught as a fawn and raised as a pet. May have had unusual feeds. |
| 179 | female | 10 months | Caught as a fawn and reared at experimental pens. Other than small amount of hay and grain had not had much unusual treatment and had been fed largely on native plants. |
| 84 | male | 1½ years | Trapped from range as short yearling. Had been held captive at pens for 1 year and maintained on native forage plants. Tested again in 1949. |
| 85 | male | 1½ years | Same as No. 84. Tested again in 1949. |

Originally it was planned that the deer would, upon completion of a digestion trial, be returned to the pens where they would be continued on a diet of sagebrush. It was found, however, that the consumption of forage while in the cages was not high, and in consequence of the poor condition of the animals, they were placed on more desirable diets as soon as they were removed from the crates. As a result only two animals were maintained on sagebrush in the open pens for a sufficiently long time to give any indications of the relative desirability of the two sages.

Table 1 gives the data relative to the four animals which were used in the digestion experiment.

During the early winter of 1948–49 four deer were placed in the cages. Two animals refused to eat appreciable amounts of sagebrush and their diet was changed. Deer 84 and 85, both of which had been used the previous year, ate sufficient amounts to permit of completing the test.

## RESULTS AND DISCUSSION

The two female animals did not eat sagebrush readily. This no doubt was attributable to the fact that they had, prior to beginning the test, been fed ground barley and alfalfa hay in addition to native forage. The males had seldom had cultivated forages and for two months prior to being placed on a sagebrush diet had been fed only native browse plants.

Table 2 shows the amounts of forage consumed by the two males while at large in the pens during March and early April, 1948.

It will be noted that big sage was much preferred to black sage. At the beginning of the feeding period equal amounts of each plant were offered. It was soon apparent that this was unnecessary and smaller amounts of black sage were collected. At all times, however, a surplus was maintained in the pens. This marked preference for big sage is the more remarkable in view of the fact that it is regarded as low in preference for domestic livestock while black sage is considered to be highly preferred by domestic livestock during the winter.

Although these two male animals were about the same size and age, deer 85 ate considerably more than did deer 84, a trend that was continued while the animals were in the cages the first winter. Weight changes in the open pens did not, however, reflect the differences in daily consumption. Deer 84 more nearly maintained his weight while in the digestion cages although he ate considerably less than deer 85. The longer feeding period may account for the greater weight loss with number 85.

TABLE 2.—CONSUMPTION OF TWO SUB-SPECIES OF SAGEBRUSH BY MULE DEER WHEN ALLOWED EQUAL OR FREE ACCESS TO EACH, AND WEIGHT CHANGE OF THE ANIMALS WHEN FED OUTSIDE THE DIGESTION CRATES (March AND April 1948).

| Deer | Deer Weight | | Average Daily Consumption Air Dry Weight (Grams) | | | Total Daily Consumption lbs./cwt. |
|---|---|---|---|---|---|---|
| | Beginning | End | No. Days | Big Sage | Black Sage | |
| 84 | 92½ | 86 | 21 | 777 | 85 | 2.1 |
| 85 | 92½ | 83½ | 31 | 1,068 | 57 | 2.8 |

The results of the digestion trials are shown in Table 3. Losses while in the cages were 1½ and 6½ pounds for deer 84 and 85 respectively in 1947–48. The following winter deer 84 lost 19¾ while deer 85 lost 8 pounds.

It is evident that the amounts of material consumed were low. Only one animal, 85, in 1947–48 consumed amounts approaching what might be regarded as adequate. It did not maintain its weight however, having lost 6½

pounds during the two week period that it was in the cage.

The digestion coefficients are in rather close agreement except for animal 84 in the first trial. The crude fiber value in this case is especially at variance from the results secured with the other animals. It seems possible that some error may have been made in recording the original data. The values could not be verified and, hence, the figures are reported with some reservations. The results in this case were excluded from the averages given in Table 3. Based upon the average values for the first tests the digestible nutrients per pound of material are shown in Table 4.

These results suggest that big sage is a readily digestible and nutritious feed. Further it was eaten readily in an earlier period when offered in conjunction with other browse plants. In no instance did a deer maintain his weight while eating of it. The food intake, however, was less during the period than was observed during the summer when the animals were on full feed. This may have been due to the nature of the forage, i.e. there may be some qualities that prevent animals eating sufficient amounts of sagebrush. It was observed

TABLE 3.—DAILY INTAKE OF NUTRIENTS AND DIGESTIBILITY COEFFICIENTS OF BIG SAGEBRUSH WHEN EATEN BY MULE DEER

| Deer | Year | Dry Weight of Forage Consumed (lbs./cwt.) | Protein | | Ether Extract | | Crude Fiber | | Nitrogen free ext. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Grams Consumed | Per Cent Digest. | Grams Consumed | Per Cent Digest. | Grams Consumed | Per Cent Digest | Grams Consumed | Per Cent Digest. |
| 83 | 1947–48 | 1.44 | 52.0 | 65.1 | 64.5 | 68.5 | 90.0 | 50.3 | 280.6 | 78.8 |
| 179 | 1947–48 | 1.39 | 41.2 | 65.2 | 55.2 | 68.1 | 74.3 | 45.5 | 219.0 | 76.3 |
| 84 | 1947–48* | 0.98 | 40.6 | 61.5 | 53.5 | 63.0 | 62.6 | 25.4 | 202.3 | 71.3 |
| | 1948–49 | 0.95 | 65.4 | 67.2 | 70.7 | 66.2 | 120.2 | 54.3 | 296.8 | 79.5 |
| 85 | 1947–48 | 2.14 | 92.5 | 65.5 | 97.4 | 73.7 | 147.4 | 51.6 | 395.1 | 78.6 |
| | 1948–49 | 0.99 | 70.6 | 70.2 | 71.1 | 64.5 | 132.8 | 54.4 | 289.9 | 77.0 |
| Average Digestibility | | | | 66.6 | | 68.3 | | 51.3 | | 78.0 |

* No values used in determining averages.

TABLE 4.—DIGESTIBLE NUTRIENTS PER 100 POUNDS OF SAGEBRUSH, KENTUCKY BLUEGRASS, AND ALFALFA. (DRY WEIGHT BASIS)

| | Sagebrush | | Green Alfalfa* | Kentucky* Bluegrass |
|---|---|---|---|---|
| | Average Composition Per Cent | Digestible Nutrients (Pounds per 100 Pounds) | | |
| Protein | 11.0 | 7.4 | 13.4 | 7.6 |
| Ether extract | 12.9 | 8.8 | 1.5 | 1.9 |
| Crude fiber | 19.9 | 13.0 | 11.5 | 46.8 |
| Nitrogen-free extract | 52.5 | 41.0 | 29.5 | |

* Adapted from Henry and Morrison.

that the animals showed definite aversion to individual plants. This may have accounted for the failure to ingest sufficient feed. No basis has been established to account for the varied palatability of different plants. Plans are to investigate this more fully.

## SUMMARY

During January and February of 1948 two mule deer were maintained on a diet restricted to *Artemisia tridentata*. Two males were fed, one for a period of three weeks, and the other for one month, material from two subspecies of sagebrush, *A. t. nova* and *A. t. typica*.

Neither deer was able to maintain his weight during the period of feeding, although the weight losses were not marked nor were they greater than weight changes during an earlier period when a variety of winter browse was offered. There was a marked difference in consumption between the two animals.

Little of the material of *A. t. nova* was consumed by either animal.

Four animals in 1948 and two in 1949 were confined to digestion cages and fed on a diet of leaves and twigs of *A. t. typica*.

Digestion coefficients of five of the animals were reasonably uniform. The results secured from the sixth test differed considerably from data secured from the other tests. Analysis of the data secured from this one animal indicates an error which because of its nature could not be checked. Digestible nutrient values of sagebrush are about half as high for digestible protein and twice as high for digestible fat and carbohydrates as is green alfalfa.

In spite of the high values of digestible nutrients all animals lost weight. This may have been due to animals failing to eat well while confined, or to some quality of the sagebrush not expressed by standard chemical analysis.

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# BREEDING RECORDS OF WHITETAIL DEER IN THE UPPER PENINSULA OF MICHIGAN

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Ask any deer hunter, "When do Michigan whitetails breed?" and he will probably say, "During the month of November." To be sure, many hunters talk of seeing matings occur during the buck hunting season which in Michigan extends from November 15 to 30. Actual dates when successful matings were supposed to have occurred, however, are difficult to secure. Accurate information of fawning dates is even scarcer. When we consider how secretive a deer is, it is little wonder that such information is notably lacking in literature. Information on the breeding season, however, is important in management. For this reason, the following data are presented, even though most of them were secured from captive animals.

General information of the breeding habits of whitetail deer has been reported by Newsom (1936), Lantz (1910), Brown (1936), and Cheatum and Morton (1942 and 1946). Little information has been published on the time of copulation and fawning, and the gestation period of deer. In the years 1937 to 1942, a considerable number of deer used in nutritional studies were held in pens at C.C.C. Camp Cusino, near Shingleton, in the Upper Peninsula of Michigan. In 1939, this same site became the headquarters of the newly established Cusino Wildlife Experiment Station.

In the fall of the year special handling of the captive deer made it possible to secure data on the breeding season. Since feeding experiments were not carried out in the fall season, the deer were fed a regular diet of browse, legume, hay, and grain to keep them in good condition. The does, each marked with a numbered ear-tag, were confined in individual pens measuring 50×100 feet. The bucks were not permitted to run with the does but were confined in separate pens. Each day a buck was placed in each of the pens with a doe. While in the pen the buck and doe were watched constantly. As soon as he had serviced her or when it became obvious she would not receive him the buck was removed. Once a doe had been serviced, no more bucks were put with her that season. Until a doe had been covered, a buck was placed in her pen each day. When the animals were put on the experimental diets after the close of the breeding season, they were frequently confined in family groups, consisting of a buck, a doe, and a fawn. Other experimental groups consisted of three or more fawns or three or more pregnant does.

The special diets were fed in periods lasting from three weeks to roughly four months. Accordingly, the pregnant does in some of the experiments suffered severe nutritional deficiencies. In many cases, the animals failed to survive. In other experiments, they were brought back into good condition by placing them on a more satisfactory diet as soon as they had lost about 30 per cent of

their body weight. From the information it is obvious that many of the does from which the breeding data were collected, had a rough time getting through the winter, which is frequently true in the wild also. Frequent starvation losses bear witness to this struggle to stay alive where food is scarce.

Crews of C.C.C. employees were used to do the work connected with the project. The work program was organized and supervised by the Game Division of the Michigan Department of Conservation, with L. A. Davenport in charge of local operations.

## BREEDING DATES

Records were secured of thirteen matings by the penned whitetails. These occurred on October 9, November 4, 5, 9, 13, 16, 17, 18, 19, 20 (two), 22, and on December 5. Seven of the thirteen matings occurred between November 16 and 22, which coincides with the first week of the deer hunting season in Michigan. Only five of the thirteen matings occurred prior to the buck hunting season which opens on November 15 each year. Data are also available for two matings observed in southern Michigan, on November 14 and 28.

Because matings are so seldom seen in the wild, it is impossible to evaluate what if any effect confinement in pens may have had on the breeding habits of the deer. It is true that hunters sometimes report having seen deer copulate. However, hunters are usually unable to recall the exact date of such incidents. Then, too, sportsmen's observations are usually limited to a single week, during the first part of the hunting season which opens November 15. Observations by hunters, accordingly do not give a true cross section of the mating season.

In the short period that a doe is in heat she may be served several times by a buck. The period she will receive a buck lasts only about a day. Morton and Cheatum (1942) working with whitetails in New York concluded that this oestrus period lasted a maximum of 36 hours and was probably concluded within a 24-hour period. Casida (1932) quotes McKenzie and Phillips (1930) as finding that in sheep the duration of oestrum was 26.8 hours.

Does in the wild are known to attract bucks when in heat. In the breeding season it is not uncommon for a hunter to see a buck with his nose to the ground trailing along a runway like a hound in pursuit of a rabbit. On two occasions, one of the authors saw a doe moving along at a fast trot, with a buck following close behind. As soon as she stopped, he mounted. On one of the occasions the animals were disturbed before the copulation was completed. They then trotted into some brush about 100 yards farther away where the mating was concluded. The buck seemed oblivious to the surroundings but the doe remained on the alert at all times, even lowering her head and looking around the brush and lower branches for signs of danger.

If a mating is unsuccessful, a doe will come into heat again in 28 or 29 days (Cheatum and Morton, 1942).

## FAWNING

Forty-two fawning dates were recorded during the study. The earliest fawn was dropped on May 9, and the latest on July 11. Twenty-three (55 per

cent) of the 42 fawns, however, were dropped in the 11-day period from May 31 through June 10. Births of the remaining 19 young were scattered over a period of 22 days before and 31 days following the 11-day peak period. Occasionally fawns are reported dropped considerably out of season. An example of this is the fawn born on about September 1, 1948.

TABLE 1.—GESTATION OF WHITETAILS IN MICHIGAN

| Number | Bred | Fawned | Gestation | Age at Fawning | Number Fawns |
|---|---|---|---|---|---|
| 3010 | Nov. 18 | June 5* | 200 Days | 3 | 2 |
| 2581 | Nov. 9 | June 19 | 222 Days | 3 | 1 |
| 2018 | Nov. 5 | May 31 | 207 Days | | 1 |
| 2065 | Nov. 4 | May 31 | 207 Days, 18 hrs., 27 min. | 2† | 1 |
| 2084 | Dec. 5 | June 19* | 197 Days | 3 | 1 |
| 2097 | Nov. 20 | June 15 | 207 Days | | 1 |
| 2033 | Nov. 16 | June 5 | 201 Days | 4† | 1 |
| 2033 | Nov. 13 | June 3 | 202 Days | 5† | 2 |
| 665 | Nov. 17 | June 3 | 198 Days | 3 | 2 |
| 617 | Nov. 20 | June 6* | 199 Days | 4 | 1 |

* Leap Year.
† Adult when tagged, therefore, this is the minimum age.

The gestation periods as determined for 10 does ranged from 197 to 222 days, with nine of the periods falling between 197 and 208 days. The average period for these 10 deer is 204 days. Cheatum and Morton (1946) working with deer in New York reported three gestation records for whitetails; namely, 189, 200, and 202 days. If these records are included, the average period is 202.5 days.

The gestation of doe number 2065 was recorded as 207 days, 18 hours, and 27 minutes. The bearing of the fawn by this deer, which was 2 or more years old at the time of fawning, was observed. The notes read as follows:

"At 10.30 A.M., 5/31/38, as the boys were feeding the animals we noticed doe 2065 in pen 9 acting strangely. Upon closer examination the front forelegs of a fawn could be seen protruding from her vagina. She did not seem, however, to be in any great pain. The legs protruded about 2″ at first. We immediately hid and watched her as she paced around a moment and then laid down in a far corner of the pen. As we watched she made panting motions lifting the tail and straining with each breath. Slowly, the rest of the fawn followed the feet out and when it was about ¾ of the way out she got up and moved around with the fawn dangling but he fell out in a moment and she immediately started licking him. The actual time of birth was 10.42 A.M. A few minutes later the fawn started nursing. This fawn will be called number 5."—by J. R. Morris.

There is some question as to the effect of the severe dietary deficiencies on the period of gestation of the penned does. Such deficiencies, however, are now commonly suffered by wild deer in the Lake States region. This is obvious when we consider the sizeable winter starvation loss in this region in both normal and severe winters.

No information is available to show that the gestation periods were prolonged because of undernourishment. Kleinheinz (1911), working with sheep, concluded that whenever a ewe carried

TABLE 2.—SIZE OF FAWNS AT BIRTH*

| Date of Birth | Age of Doe at Fawning | Fawn | | | | | | Single | Twin |
|---|---|---|---|---|---|---|---|---|---|
| | | Sex | Weight | Tail Length | Ear Length | Foot Length | Total Length | | |
| | | | lb.-oz. | in. | in. | in. | in. | | |
| 5-23-38 | | M[a] | 5–7 | 4 | 3½ | 10¼ | 26½ | | X |
| Twin | | M[a] | 5–5 | 4 | 3¼ | 9½ | 28 | | X |
| 5-27-41 | 5 | F[b] | 8–2 | 5 | 3¼ | 10¼ | 28 | | X |
| Twin | | M[b] | 7–2 | 5¼ | 3½ | 10 | 27¾ | | X |
| 5-27-38 | | M | 8–4 | 4½ | 3¼ | 11 | 28 | X | |
| 5-31-38 | | F | 5–4 | 4¼ | 3 | 9½ | 26 | X | |
| 5-31-39 | 2 | M | 7–12 | 6½ | 4 | 12 | 26 | X | |
| 6- 1-38 | | M | 7–8 | 4 | 3¼ | 9¾ | 26 | X | |
| 6- 1-41 | 5 | M | 10–0 | 5½ | 3¾ | 13¾ | 29 | X | |
| 6- 3-38 | 2 | F | 3–4 | 4 | 2½ | 8½ | 21 | X | |
| 6- 4-38 | 2+ | M | 5–7 | 4 | 3½ | 10¼ | 26½ | X | |
| 6- 4-40 | 4 | M | 14–8 | | | | | X | |
| 6- 5-39 | | F | 6–8 | 3¼ | 2¼ | 9¾ | 25 | X | |
| 6- 5-39 | | M | 5–0 | 4¼ | 3¼ | 9½ | 23¾ | X | |
| 6- 5-38 | | F[c] | 6–8 | 4½ | 3¼ | 10½ | 25½ | | X |
| Twin | | F[c] | 5–12 | 4½ | 3¼ | 9½ | 23½ | | X |
| 6- 7-38 | | M[d] | 4–8 | 3½ | 3¼ | 9 | 22½ | | X |
| Twin | | F[d] | 3–8 | 3¼ | 2¾ | 8½ | 21 | | X |
| 6- 7-39 | 3+ | M | 9–4 | 4½ | 3¼ | 10½ | 26¾ | X | |
| 6- 7-39 | | M | 8–0 | 5 | 3½ | 11½ | 26½ | | |
| 6- 7-39 | 3 | F | 8–4 | 4 | 3¼ | 10½ | 26 | X | |
| 6-10-38 | | F | 3–4 | 3 | 3 | 9 | 27½ | X | |
| 6-13-40 | 3 | F | 5–8 | 4¼ | 3 | 9½ | 23¾ | X | |
| 6-14-39 | | F | 6–4 | 3½ | 3¼ | 9¾ | 23¼ | X | |
| 6-15-39 | | M | 6–0 | 3¾ | 3 | 9¼ | 23½ | X | |
| 6-15-39 | | M | 6–0 | 3 | 3¾ | 9¼ | 23½ | X | |
| 6-21-36 | | M | 7–8 | 6½ | 3¼ | 10 | 26 | X | |
| 6-31-38 | 2+ | M | 9–0 | 5 | 3¾ | 9¾ | 27 | X | |
| 7-11-39 | 2 | F | 6–8 | | | | | X | |
| Average for female fawns | | | 5–11½ | 4.0 | 3.0 | 9.6 | 24.2 | | |
| Average for male fawns | | | 7–7 | 4.6 | 3.4 | 10.3 | 26.1 | | |

* All measurements and weights were taken within two hours after birth. Measurements were taken as follows: ear—notch to point; hind foot—hock to tip of hoof; total length—tip of nose to end of tail vertebrae.

[a] —twins.
[b] —twins.
[c] —twins.
[d] —twins.

her lamb from 5 to 7 days overtime, the result was usually a weak or dead lamb. The single fawn born at the end of the 222 days of gestation, actually was carried about three weeks overtime. It weighed 9¼ lbs. at birth and seemed normal except for being a little larger than the average fawn at this age. Kleinheinz concluded that outdoor exercise resulted in an increase in the

number of ewes dropping their lambs one to five days ahead of the usual 147 days.

If confinement has any effect on gestation in deer, then it would be expected that such effects might be to lengthen the gestation period by a very few days. If the condition found in sheep also exists in deer, then it might be expected that the average gestation period for wild whitetails would not be longer than the indicated 204 days for 10 penned deer, but might be two or three days shorter.

Newsom (1926) states that whitetail fawns weigh "four or five pounds at birth." Twelve Cusino female fawns had an average weight of 5 pounds, 11½ ounces, the 17 male fawns, however, were a little heavier, averaging 7 pounds, 7 ounces. On an average, the males were larger in both weights and measurements. It is not known to what extent if any, the dietary deficiencies caused by the feeding experiments, may have influenced the weight and size of the fawns at birth. The single fawn weighing 14 pounds, 8 ounces, born to a three-year old doe is the heaviest one for which we have a record.

## DISCUSSION

The relatively few records on the rutting season indicate that in Michigan's Upper Peninsula a considerable part of the doe population is bred after the opening of the deer hunting season. The question might be asked, "Shouldn't the opening of the deer season be delayed a week and open on November 22 or 23 so as to allow more of the does to be bred before opening the season?" To this question can be replied that "In spite of the apparent overlap of the rutting season and the hunting season, the deer herd seems to have been doing well, in fact so well that some areas have become overpopulated and overbrowsed." In many parts of Michigan today we are not harvesting as many bucks as the population permits. If the hunting season were delayed until after the rutting season fewer bucks would be on the run and, therefore, fewer of our surplus deer would be harvested. So long as the doe population is stocking our habitats to capacity it can be considered good management to establish a season making it possible to take a maximum number of the surplus bucks. It is also good management to harvest any surplus in the doe and fawn population where the habitat is overstocked and overbrowsed by deer. In many cases, buck laws prevent proper harvesting of surplus does and fawns.

Another good reason for not delaying the opening of the deer season until a later date in Michigan's Upper Peninsula is that hunters are likely to become snowbound anytime after about November 20. In the fall of 1948, a snowfall of 1.1 feet on November 20 scared many Upper Peninsula deer hunters out of the woods after only five days of hunting. The reason that the snow affects hunting so much in the Upper Peninsula is that much of the deer hunting territory is accessible only by little-used roads and logging trails. To delay the opening of the deer season in this area would mean that harvesting of the surplus crop of deer would be prevented in some years. This would result in further destruction of the habitat and a waste of a crop of surplus animals.

The authors wish to acknowledge the valuable contributions of Ford Kellum, Game Biologist with the Michigan Department of Conservation, who shouldered the responsibility of carrying out work details connected with the project.

## SUMMARY

Observations on penned deer indicate that whitetail does in the Upper Peninsula of Michigan are bred mainly during the middle of November. Fawns are dropped mainly between May 31 and June 10, after an average gestation period of 204 days.

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# AERIAL CENSUS OF INTERSTATE ANTELOPE HERDS OF CALIFORNIA, IDAHO, NEVADA, AND OREGON

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## INTRODUCTION

California, Oregon, and Idaho have been making separate aerial censuses for several years to determine the status of their antelope herds and to serve as a basis for recommending open or closed seasons.

For some time these and other western states have known that interstate migration occurs annually among herds ranging in the vicinity of State boundaries. In addition, the U. S. Fish and Wildlife Service in the course of publishing annual big game census figures for the United States, has questioned the degree of duplication that has occurred in estimating these interstate herds. To answer this mutual problem the States of California, Nevada, Oregon and Idaho agreed to an aerial census of all antelope herds simultaneously. This initial cooperative inventory was accomplished in March 1949. The map on the following page shows antelope winter range and numbers observed.

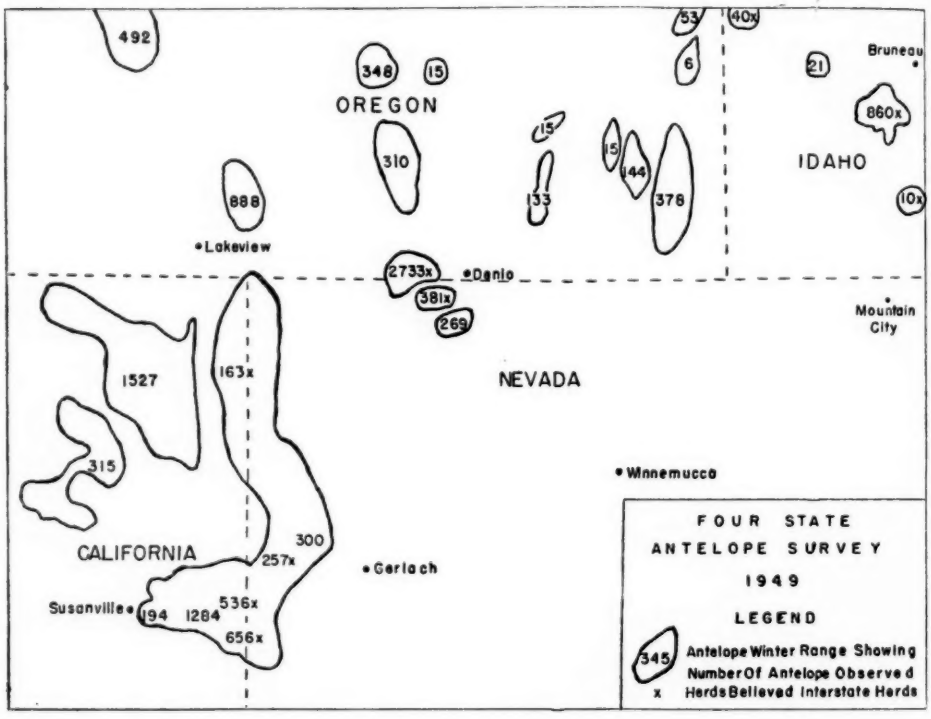
## CENSUS

Antelope were most conspicuous in the early morning and late afternoon hours on the desert plains when the light was striking them at an acute angle. By flying low between the antelope and the sun they were sighted at considerably greater distances during these periods. In mountainous terrain it was found most satisfactory to count antelope after the sun was higher, but before the air became rough toward midday. In some areas inclement weather necessitated censusing whenever flight conditions permitted.

Wherever possible, greatest accuracy was achieved by making parallel flights and progressively covering the area or drainage. The distance between flight strips varied with the topography, ground cover, and lighting conditions, so that all of the area between strips could be observed.

The best results were obtained by establishing census area boundaries using roads, streams, and other landmarks for this purpose and then progressively flying these sections. The flight strips, antelope, and terrain were most easily and accurately checked when the flight lines were kept within five-mile lengths.

The course flown on the census strip was outlined on Civil Aeronautics maps by most of the States and the number of animals seen were then likewise recorded on the maps along the route traveled. Observations were usually



best when made from about 200 feet above the ground, in level country with smooth air, but in mountainous regions, or rough air the census had to be flown up to 500 feet to maintain a reasonable safety margin.

California and Idaho used an aerial camera to record photographically all groups of antelope greater than 10 or 12. The use of cameras increased accuracy and reduced flying time to about one-third of that necessary to make counts of large bands. Idaho found visually they counted 1,146 antelope in Owyhee County, while the photographic enumeration revealed only 960. The State of California used a K-20 hand camera and attempted to take pictures of the larger groups of animals from about 700 feet. All photographs were taken away from the sun with an oblique shot at an angle greater than 45 degrees. The pictures were taken only when the animals were moving away from the plane.

Most satisfactory results were achieved when fine grain film was used and prints were made on high contrast paper. Photographs of extensive groups of animals were enlarged as much as possible and counting was done with the aid of a reading glass. As each animal was counted the white rump patch was perforated with a sharp instrument. This procedure avoided duplication and permitted rechecking the count.

SUMMATION OF CENSUS

| State | Antelope Seen | Hours Flown | Average Cruising Speed | Observers | Type Plane | Horsepower |
|---|---|---|---|---|---|---|
| California | 4,675 | 15½ | 110 | D. McLean | Fairchild M-24 | 165 |
| Idaho | 960 | 23½ | 105 | M. Crooks and W. Shaw | Cessna 170 | 145 |
| Nevada | 257* | 3½ | 110 | D. McLean | Fairchild | 165 |
| Nevada | 950 | 22½ | 85 | N. Nilsson & R. Hanson | Cub Cruiser | 100 |
| Oregon | 4,016 | 37½ | 80 | Ellis Mason | J-5 | 80 |
| Oregon | 1,076 | 21 | 80 | C. Langdon | J-5 | 80 |
| Oregon | 1,432 | 7½ | 90 | Bill Lightfoot | Super Cruiser | 100 |
| Oregon | 513 | 6¾ | 90 | Paul Bonn | Super Cruiser | 100 |
| Total | 13,879 | 137¾ | 89 | | | |

* The Buffalo Mountain herd was counted by both California and Nevada. California's count was larger and this figure was used. This adds 57 to Nevada's total making 1,207 for Interstate herd.

A small, slow plane with a cruising speed of about 85 miles per hour and having an engine of at least 85 horsepower has been found the most practicable for aerial census work. Observation is much better from a high-winged plane, and all States used this type.

The most severe winter in recent history delayed the survey by two or three weeks. Most of the antelope observed were below 5,000 feet elevation which coincided with the lower limits of the snow in most areas. Antelope were observed on the valley floors or on protected slopes where snow was absent or occurred only in scattered patches. The greatest concentration was 2,733 ani-

mals tallied on approximately 150 square miles of habitat situated west of Denio, Oregon. The antelope estimates for 1948 and the revised estimates after the interstate census are found in the following table.

ESTIMATED STATE TOTAL ANTELOPE POPULATION AND CORRECTION FROM THE INTERSTATE ANTELOPE CENSUS

| State | Population | | Revised Population Est. from Interstate Census |
|---|---|---|---|
| | 1948 Est. | 1949 Est. | |
| California | 4,500 | 4,700 | + 200 |
| Idaho | 7,600 | 7,739* | + 139 |
| Nevada | 7,000 | 3,500 | −3,500 |
| Oregon | 12,000 | 14,000 | +2,000 |
| Total | 31,100 | 29,939 | −1,161 |

* Actual Count.
Oregon's increase in population is due to natural increase with a good fawn survival.

Nevada for the last several years has estimated 5,000 antelope in the northwestern part of the state for the annual big game inventory. After the interstate census they were of the opinion that part of the 1,192 animals wintering in California east of Wendel summer in Nevada in the mountains north of the Smoke Creek Desert.

A summer antelope census on the Charles Sheldon Refuge in Nevada during 1948 counted 1,120 animals and a similar census on the Hart Mountain Refuge in Oregon in 1949 counted approximately 1,500 animals. The total of these two figures is nearly the exact number found wintering west of Denio during the interstate census.

This would indicate that even a summer estimate of 5,000 for the northwestern part of Nevada would be too high. Annual big game estimates are made on the number of animals on their winter range so that even if this number summered in Nevada and wintered in other states, it would be necessary to reduce the state's total population estimates to the number counted on their winter ranges.

## SUMMARY

The first four-state antelope census was flown in March 1949. A total of 137¾ hours or 12,350 miles were flown and 13,879 animals were observed. It is believed about 5,000 of these animals migrate back and forth across state lines.

The census was the first complete aerial coverage for northwestern Nevada and only 1,207 animals were found. The state had previously estimated 5,000 head wintering in this area.

Antelope were not found in the Owyhee Desert, High Rock Canyon and High Rock Lake areas. It was formerly believed that antelope wintered in these areas. Additional censuses are needed at different seasons of the year to determine seasonal population in northwestern Nevada and to decide if abnormal concentrations were found this year due to severe winter weather.

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# THE RELATIONSHIP OF MUSKRAT POPULATIONS TO VARIOUS MARSH AND AQUATIC PLANTS

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The primary objectives of this study were to determine plant food preferences of the muskrat (*Ondatra zibethica*), in winter and the relative muskrat populations supported by various marsh plants in Illinois. Secondary objectives were to evaluate the influence of depth of water and fluctuating water levels on density of dwelling houses and the relationship between dwelling and feeding houses.

These investigations were conducted on the bottomland lakes of the Illinois River valley in the fall-winter seasons of 1940–41 and 1943–44, and on the glacial lakes of Lake County in northeastern Illinois in the 1943–44 season. They are a sequel to a study made in 1939–40 by Bellrose and Brown (1941) on the influence of fluctuating water levels and vegetation on muskrat populations in the Illinois River valley.

## Procedure

During late summer when the growth of marsh and aquatic vegetation was at its peak, type maps of the vegetation were drawn on base maps which were usually scaled $5\frac{1}{4}$ inches to the mile. In the following January and February, when the lakes were solidly frozen, the numbers and distribution of muskrat dwelling and feeding houses were recorded on the summer vegetation maps. In all but a few cases, it was possible to directly plot the location of the houses on the maps. Where the density of houses made this impossible, their general distribution was shown, and a figure inserted on the map indicating the total number in each vegetation type. Water depths were noted during the summer and again at the time of the house plotting; on the lakes in the Illinois River valley it was possible to check the levels during the intervening period by river gauge recordings.

At the time of plotting muskrat houses, certain feeding houses were opened with a few axe strokes. By reaching into the water at the plunge hole, all vegetation was collected until the bottom, or a rotting mass of old vegetation was reached. This vegetative material, brought in as food by muskrats, was placed in a paper sack and numbered, and a corresponding number was placed on the map where the sample was taken. When possible, feeding houses were selected with only two kinds of plants about equally available within a 20–30 yard radius. If the type map failed to show local vegetation in sufficient detail, notes were taken on the relative proportion of plants judged to fall within the radius of the muskrats' feeding activities. After prolonged air-drying or quick oven-drying, the plant material was removed from the paper bags, separated into components of species and vegetative parts and weighed.

By comparing the proportion of food material found in each feeding house sample with that available in the surrounding feeding radius area, it is be-

lieved that a fairly accurate appraisal was made of the muskrats' relative winter food preference of various marsh and aquatic plants. On the basis of food preference and the number of houses per acre for various types of vegetation, an evaluation is made of the various plants for muskrats in Illinois.

## FEEDING HOUSES AND FOOD ANALYSES

Food material was taken from feeding houses rather than dwelling houses because of the greater ease of cutting open and plugging and because the smaller size made it easier to find the food which is usually present at the open water of the plunge hole. Feeding houses, as delineated here, are smaller than dwelling houses. Whereas dwelling houses varied from 20 to 46 inches in height above the ice, feeding houses were from 6 to 18 inches high. Whereas the elliptical dwelling houses measured 4 to 6 feet in long diameter, feeding houses measured only 1.5 to 2 feet in diameter and were more oval in shape. Walls of dwelling houses varied from 12 to 24 inches in thickness while those of feeding houses were from 3 to 8 inches thick. Although there was an intergradation in size and shape so that about two dwelling houses were opened by mistake for every 100 feeding houses examined, the determining factor was the presence or absence of nest chambers. Feeding houses have no nest chambers and very seldom more than one plunge hole. Two plunge holes are usual for dwelling houses. Other type of structures made by Illinois muskrats are pushups and platforms. Pushups are made of vegetation pushed up along the rim of an opening in the ice or placed over a small hole in the ice. Platforms or rafts, as the name implies are collections of floating plant material.

Sometimes partly eaten food particles were found floating on the water surface on the open plunge holes of both dwelling and feeding houses. However, below the water surface in the plunge hole was found the bulk of the plant material and occasionally some animal material. This material from all appearances had been brought in by muskrats solely for feeding purposes. The average weight of the plant material, air dried, amounted to 47.2 grams per active feeding house. In certain areas little or no plant food material was found in feeding or dwelling houses.

In some instances the plant material found as stored food or food remnants in feeding or dwelling houses may reflect unwanted items rather than the desirable ones—the choice items having been entirely consumed. However, it is believed that the bulk of this material is in proportion to its use as food. As pointed out by Svihla and Svihla (1931) and Takos (1947) the muskrat wastes as much vegetable food as it consumes. It was common to find a half dozen partly eaten tubers of the same plant at one feeding place. Tubers and roots of cattails and bulrushes were found in more than twice the quantities of their stems, leaves and shoots. From the analysis of marsh plants by Stearns and Goodwin (1941) it is evident that the roots of marsh plants are much more nutritious than the tops. Plants that could logically be assumed to be more palatable and nutritions than others which were equally available were al-

most invariably in greatest quantities in the feed piles. When more than one plant was available, the feed pile in feeding and dwelling houses generally differed in composition from the house material.

### FOOD SELECTIVITY

Because of the difficulty of assaying and identifying the finely ground material in muskrat stomachs, most studies of muskrat foods have been based upon general observation and the recording of items on feeding rafts during non-winter months. However, Stearns and Goodwin (1941) analyzed samples of the finely ground stomach contents for moisture, ether extract, crude protein, crude fiber, ash and nitrogen-free extract and compared these results with the composition of ten plants representative of the vegetative cover where the muskrats were trapped. They concluded that the high crude protein of the stomach contents indicated that muskrats in Delaware obtained a substantial quantity of protein from animal sources during the winter months.

It is apparent that muskrats have varied feeding habits. Errington (1941) discusses the versatility of their feeding and states that there is little or no selectivity in feeding behavior of some individuals. Takos (1947) in an intensive study on a 45-acre marsh from April to September concluded that muskrats fed on the most abundant and most conveniently obtained food.

Our studies in Illinois reveal that, while there is a great deal of individual variation in food habits, muskrats had a marked preference for some plants. (Tables 1 and 2.) In contrast, muskrat houses are generally composed of plants immediately surrounding the lodge site, but even there, we have observed that water depths may affect selectivity. For example, at Rice Lake, 1940–41, about 90 per cent of the houses placed

TABLE 1.—FOOD PREFERENCE OF MUSKRATS IN RIVER BOTTOM LAKES OF THE ILLINOIS RIVER, 1940–41 AND 1943–44

| | Lake or Marsh Area and Number of Samples at Each | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Chautauqua | Douglass | Starved Rock | Rice | Rice 1944 | Beebe | Goose Pond | Goose Lake | Total |
| | 23 | 20 | 8 | 35 | 5 | 9 | 7 | 6 | 113 |
| River Bulrush Index value | 2.05 | 1.68 | 1.90 | 1.02 | 1.44 | 1.31 | 1.87 | 1.33 | 1.50 |
| Marsh Smartweed Index value | 1.06 | 0.85 | | 1.17 | 0.61 | | | | 1.08 |
| American Lotus Index value | 0.83 | 1.16 | | 0.71 | 0.75 | 0.84 | 0.31 | 0.94 | 0.74 |
| White Waterlily Index value | | 0.33 | | 3.80 | 0.40 | | | | 1.0 |
| Wild Rice Index value | | 0.08 | | | | | | | 0.08 |
| Pickerelweed Index value | | 0.26 | | 2.10 | | | | | 1.51 |
| Duck Potato Index value | | 0.56 | | 0.57 | | | | | 0.56 |
| Cattail Index value | | | 1.64 | | 2.00 | | | | 1.66 |
| Black Willow Index value | | 0.77 | | | | | | | 0.77 |

in the ecotone of American lotus and river bulrush were composed almost entirely of lotus leaves and stalks with smaller amounts of seed heads and rootstocks. Although shallow water limited the accessibility of river bulrush for house material, this plant was taken for food at Rice Lake about one-third more than lotus. At nearby Beebe Lake where water depth necessitates the location of practically every house in American lotus, but with most of them in proximity to river bulrush, 95 per cent of the houses were composed of lotus, the rest of river bulrush. Yet an analysis of the food remnants from feeding houses disclosed that river bulrush was being taken about two-fifths more than lotus. This indicates that these muskrats made an effort to obtain river bulrush for food but not for houses.

TABLE 2.—FOOD PREFERENCE OF MUSKRATS IN THE GLACIAL LAKES OF NORTHEASTERN ILLINOIS, 1943–44

| | Lake | | | |
|---|---|---|---|---|
| | Grass | Nippersink | Sullivan | Total |
| No. of Samples | 7 | 2 | 5 | 14 |
| River Bulrush Index value | 0.87 | | | 0.87 |
| Hardstem and Softstem Bulrush Index value | 0.53 | 1.21 | 1.41 | 1.19 |
| Cattail Index value | 1.25 | 1.36 | 1.26 | 1.26 |
| Sedge Index value | 0.91 | 1.11 | 0.25 | 0.70 |
| Reed Index value | 0.45 | | | 0.45 |
| White Waterlily Index value | 1.26 | 0.70 | 1.40 | 1.08 |

Density of muskrat dwellings in wild rice beds of Douglass Lake was almost as high as in river bulrush beds. Although the houses were composed of wild rice, this plant had the lowest index food value of all the important plants there; most of the muskrats were moving through the narrow wild rice bed to feed on adjacent beds of river bulrush, pickerelweed and American lotus.

The above illustrations indicate that during winter months Illinois muskrats probably select the more nutritious and palatable plants for food when such a choice is available. They eat the more nutritious roots in greater quantities than the less nutritious stems and leaves of cattails and bulrushes.

## FOOD PREFERENCES

The food preferences of muskrats probably include plants selected for palatability and nutrition. Plants of high palatability and preference may not support so many muskrats per unit area as others less palatable but more nutritious. The amount of food produced per unit area is another factor affecting the relative value of each plant species. The preferential food importance of 12 groups of plants abundant in the muskrat habitat of Illinois are discussed in descending order of value as determined from index ratings in Tables 1 and 2.

Index ratings result from dividing the per cent of plant food material found in the houses by the availability of those plants in the feeding radius around the houses. The various food plant items in each house equal 100 per cent and the plants available for feeding equal 100 per cent. An index of 1.0 indicates a food selection as great as the availa-

bility of the plant. The higher the index the greater the food preference, and vice versa.

Cattails (*Typha angustifolia* and *T. latifolia*). In Illinois River marshes, narrowleaf cattails averaged slightly higher in food preference than river bulrush and pickerelweed. In the glacial lake marshes, both species combined averaged only slightly higher than the hardstem and softstem bulrushes. At Sullivan Lake, where cattails and the round-stem bulrushes were about equally abundant, the latter were chosen slightly more than the cattails.

The tubers of cattails were found in quantities weighing 2.3 times more than the vegetative parts, most of which were the succulent basal portions of the stems.

Pickerelweed (*Pontederia cordata*) had an index value similar to river bulrush, both of which were only slightly lower than cattails. However, because of an unusual condition at Douglass Lake, which lowered the index rating, this plant should rank higher than river bulrush. Judging from its value at Rice Lake, 1940–41, pickerelweed might be preferred even to cattails.

It ranked low at Douglass Lake because muskrats had largely consumed all the plants by the time the food material was collected in February. There was a narrow fringe of pickerelweed on the outside of the wildrice beds. Wildrice has a high house use even though it is a poor muskrat food. As a result muskrats placed the adjacent pickerelweed plants under extremely heavy feeding use. Because availability was based upon areas covered by plants in early fall, and because the remnants of pickerelweed were difficult to measure, the low index value at Douglass Lake is erroneous. Actually it was selected as food to a much greater degree than river bulrush which bordered wild rice on the other side.

The basal section of pickerelweed stems was the most preferred part of the plant. These were surprisingly succulent throughout the winter.

Hardstem and Softstem Bulrush (*Scirpus acutus and S. validus*). Because of their similarity in growth-form and in ecological requirements in Illinois, these species have been combined. With an index of 1.19, they ranked only slightly below the 1.26 index value of the cattails.

Sections of the woody root-stalks were found in 2.5 times greater quantities than the round-stem culms, some parts of which were green and succulent when removed from the houses in midwinter.

River bulrush (*Scirpus fluviatilis*) ranked close to cattails in Illinois River marshes where it is an abundant species and cattails are scarce. In glacial lake marshes it did not have such a high index of food value as the round-stem bulrushes.

Again tubers predominated in the food material found, weighing 2.6 times as much as the stems and leaves.

Marsh smartweed (*Polygonum Muhlenbergii*) is a perennial species, frequently growing in water two feet deep. In river marshes it was about equal in value to water-lily. The stems of this smartweed were found more frequently in the food material than the rootstocks. Most of the stems and rootstocks were quite succulent even in midwinter.

White water-lily (*Castalia tuberosa*)

ranked lower in value than river bulrush in river marshes but higher in value in glacial lake marshes. Although of high frequency in feeding houses, the quantities found, with the one exception, were small, usually consisting of a few unfolding leaf shoots. Omitting the one atypical sample, the leaf shoots weighed 1.2 times more than did the rootstocks.

Sedges, largely (*Carex riparia lacustris*), have an index of 0.7 in the glacial lake marshes, which is slightly less than the American lotus index of 0.74 in river marshes. With a limited choice of good food plants available, river bulrush had an index of 1.5 in river marshes but with a greater choice of good food plants available in the glacial lake region, its index dropped to 0.87. Thus it is believed that *Carex r. lacustris* is prefered over lotus as a food by muskrats.

The sedge parts found as food material consisted largely of stems.

American lotus (*Nelumbo lutea*) probably ranks below sedge but above black willow (*Salix nigra*) as a muskrat food in Illinois. At Lake Chautauqua, where muskrats located in a narrow zone of marsh smartweed had American lotus available on one side of their houses and black willow on the other, lotus was slightly favored over black willow.

At most Illinois river lakes, lotus and river bulrush were equally abundant as muskrat foods, but twice as much river bulrush was taken. At Lake Chautauqua marsh smartweed was preferred over lotus by about 5 to 4. Lotus use was comparatively high at Douglass Lake because of muskrats dwelling in the wild rice zone feeding in adjacent lotus beds.

Lotus parts used by muskrats during winter were largely the seed heads and the large leaf and flower stalks. Seed heads occurred in 20 per cent more houses than did the stalks but the dry weight of both was about the same. Frequently all that was left of the seed heads was the shredded fibrous vascular system, the surrounding matrix having been completely consumed. A few succulent leaf shoots were found.

Black willow (*Salix nigra*) was readily available to muskrats only at Lake Chautauqua where a permanently raised water level placed many of these trees in water 6 to 18 inches deep. The bark on the twigs of willow was used primarily as food with the roots a second choice.

Duck potato (*Sagittaria latifolia*) had the same low index at both Lake Chautauqua, where either marsh smartweed or river bulrush were equally available as food, and at the Starved Rock Pool, where cattails were equally available. Five times as much duck potato stem material was found as roots and tubers. Most of the stem material left consisted of only of the fibrous vascular tissues. The low utilization of tubers of this species in Illinois may result from their greater depth in bottom soil than the tubers of other marsh plants, and may also relate to the fact that unlike other marsh plants, the stems of duck potato may almost be as nutritous as the tubers or roots as evinced by Stearns and Goodwin's study (1941).

Jerome Stoudt (in correspondence, 1948) has found tubers of *Sagitturia rigida* to be an important muskrat food in the Mississippi River marshes of Wisconsin and Minnesota. He has evidence that the hardness of the bot-

tom determines to a large extent the availability of the tubers to muskrats. W. C. Truax (in correspondence 1949) also has found *Sagittaria* tubers frequently in muskrat houses at the Horicon marsh in Wisconsin. James Beer (in correspondence 1949) observed that in Wisconsin marshes *Sagittaria* was used mainly in the spring and summer when the tubers appear to be relished.

Reed (*Phragmites communis*) with an index of 0.45 in glacial marshes where cattails were equally available as a food, ranked slightly below duck potato where cattails were also equally available as a food. Stems and roots made up the food material.

Wild rice (*Zizania aquatica*) had the lowest index value of the marsh plants studied. As mentioned earlier, the relatively high population of muskrats residing in this zone were feeding largely on adjacent vegetation. The stems of wild rice made up the only part of this plant found in feeding houses during the mid-winter survey.

In addition to the above marsh plants, two underwater plants—water milfoil (*Myriophyllum* sp.) and coontail (*Ceratophyllum demersum*)—frequently occurred in the muskrat feeding habitat. They were omitted from the index value tables because of the difficulty in determining their availability to muskrats as compared with marsh plants. However, at Sullivan Lake with both water milfoil and coontail about equally abundant, milfoil occurred in the contents of feeding houses twice as frequently as coontail. Milfoil was found in 9 of the 14 samples taken in glacial lake marshes. At Douglass Lake, coontail occurred in the vicinity of 8 feeding houses but was found in only four. Winter buds of milfoil and coontail were the parts making up the bulk of these plants in the food material.

### Animal Food

In the feeding house there was little to indicate that muskrats fed upon much animal material during the winter months. Six of the 127 feeders examined contained the following animal matter: one large intact crayfish (*Cambarus* sp.); the chela of a crayfish; one half-pound grass pickerel, *Esox vermiculatus;* two heads of gizzard shad (*Dorosoma cepedianum*); one partly devoured fish; and scales of one or more fish.

### Vegetation and Population Density

Each year spring flood waters destroy almost all houses in the bottomland lakes of the Illinois River; in many years this also happens at Grass and Nippersink Lakes through which the Fox River flows. This necessitates the building of new lodges each year which is largely accomplished from late August to early October. At that time there are few inhabited bank dens because the low water level and shallow saucer-shaped basin of the lakes provide few suitable bank den sites.

Although the number of dwelling houses may not be a precise indicator of muskrat numbers, published information and our own data reveal that house counts are reliable approximations of the population. For the purpose of evaluating yearly population changes and the density in various types of vegetation, we believe the enumeration of houses provides a reliable index.

Table 3 lists the area of the principal

TABLE 3.—MUSKRAT DWELLING HOUSES IN VEGETATION TYPES AND THEIR AREA IN VARIOUS GLACIAL AND RIVER BOTTOM LAKES, SEASONS OF 1939–40 TO 1944–45

| Area | Season | River Bulrush | | Hards. Bulrush | | Cattail | | Marsh Smartweed | | Sedge | | American lotus | | Wild Rice | | Duck Potato | | Reed | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Acres | Houses per acre | Acres | Houses per acre | Acres | Houses per acre | Acres | Houses per acre | Acres | Houses per acre | Acres | Houses per acre | Acres | Houses per acre | Acres | Houses per acre | Acres | Houses per acre |
| *Glacial Lakes* | | | | | | | | | | | | | | | | | | | |
| Grass Lake | 1943–44 | 158 | 5.42 | | | 164 | 2.79 | | | 206 | 1.72 | | | | | | | 26 | 6.90 |
| Grass Lake | 1944–45 | 169 | 0.65 | | | 107 | 0.85 | | | 108 | 0.68 | | | | | | | 39 | 0.60 |
| Sullivan Lake | 1943–44 | | | 162 | 0.20 | 66 | 0.92 | | | | | | | | | | | 1 | 0 |
| Nippersink Lake | 1943–44 | | | 14 | 3.60 | 22 | 1.60 | | | 24 | 1.48 | | | | | | | | |
| *River Lakes* | | | | | | | | | | | | | | | | | | | |
| Starved Rock | 1939–40 | 4 | 3.00 | | | 42 | 6.70 | | | | | | | | | 18.6 | 0 | | |
| Starved Rock | 1940–41 | 3 | 2.30 | | | 41.9 | 4.44 | | | | | | | | | 61 | 1.77 | | |
| Goose Pond | 1939–40 | 466 | 0.44 | | | | | | | | | 45 | 0 | | | 18 | 0 | | |
| Goose Pond | 1940–41 | 673 | 0.71 | | | | | | | | | 227 | 0 | | | | | | |
| Douglass Lake | 1939–40 | 1,350 | 0.27 | | | | | 21 | 0.28 | | | 132 | 0.10 | 81 | 0.20 | | | | |
| Douglass Lake | 1940–41 | 832 | 1.35 | | | | | 43 | 1.30 | | | 277 | 0 | 42 | 1.43 | | | | |
| Beebe Lake | 1940–41 | 333 | 0 | | | | | | | | | 525 | 0.52 | | | | | | |
| Goose Lake | 1940–41 | 61 | 0.47 | | | | | | | | | 393 | 0.12 | | | | | | |
| Rice Lake | 1939–40 | 414 | 0.42 | | | | | 18 | 4.40 | | | 163 | 4.30 | | | | | | |
| Rice Lake | 1940–41 | 413 | 0.52 | | | | | 13 | 5.40 | | | 317 | 1.23 | | | | | | |
| Rice Lake | 1943–44 | 385 | 0.50 | | | | | 61 | 3.18 | | | 64 | 0.84 | | | | | | |
| Rice Lake | 1944–45 | 360 | 0.54 | | | | | 72 | 1.20 | | | 156 | 0.88 | | | | | | |
| Lake Chautauqua | 1939–40 | 36 | 7.20 | | | | | 159 | 5.30 | | | 78 | 4.80 | | | | | | |
| Lake Chautauqua | 1940–41 | 10 | 7.40 | | | | | 157 | 3.18 | | | 207 | 0 | | | 23 | 2.56 | | |
| Jack Lake | 1940–41 | | | | | | | 124 | 0 | | | 398 | 0.29 | | | | | | |

marsh vegetation types and the houses per acre in each type for the lakes studied. Data for the 1939–40 season are taken from a previous paper by Bellrose and Brown (1941). The house density per acre of vegetation may or may not indicate the relative value of a particular type depending also upon depth of water, fluctuation of water levels and availability of other food plants.

## VALUE OF MARSH PLANTS

The value of various species of marsh plants for muskrats probably can best be measured by the comparative density of the dwelling houses. The food value ratings may not necessarily indicate the true value of a plant for muskrats, for the ratings do not take cognizance of the amount of food available nor its nutritional quantities which must be important factors in determining muskrat use. Other values plants have for muskrats are for anchorage and house construction.

Although cattails were preferred as food to river bulrush, the latter may support more muskrats. The highest house density occurred in river bulrush beds; low densities in that type are attributable to the low water depths or the effect of fluctuating water levels.

Cattails and marsh smartweed supported similar high house densities. At Nippersink Lake, there was a greater density in hardstem bulrush than in cattail beds. However, this resulted from the more favorable depth of water in the hardstem bulrush zone. At Sullivan Lake where water depths in both cattails and hardstem bulrush were excellent, there were over four times as many houses per acre in cattails as in hardstem bulrush. Since this bulrush was only slightly lower in food preference than cattails, the difference in value may lie in the amount of food available per unit of area. The value of hardstem bulrush for muskrats in Illinois is below that of marsh smartweed but above that of reed cane and sedges.

Marsh smartweed did not occur in sufficient abundance in lakes with cattails or hardstem bulrush to permit direct appraisal of their relative values for muskrats. However, the years that stable water levels prevailed at Rice and Chautauqua Lakes, house densities in marsh smartweed were greater than those in cattails at Grass Lake and were similar to the density in cattails at Starved Rock Pool during the 1939–40 and 1940–41 seasons. Grass Lake and Starved Rock Pool had water levels more stable than Rice or Chautauqua Lakes, but unfavorable minimum water depths prevailed to a greater extent in the cattail beds of Grass Lake than in the marsh smartweed beds of Chautauqua or Rice Lakes. Appraising these incongruous factors are difficult, but it would appear that cattails have the edge over marsh smartweed in value for muskrats.

Reed cane occurred in small patches rather than in extensive tracts, so muskrats residing in it usually had access to cattails or river bulrush. The high density of houses despite low food preference indicates that this plant has other qualities. In mid-winter it provides houses with good anchorage. Even so, when there is room for lodges in plants of higher food value, muskrats may move from reed cane. That happened on an 11-acre cattail-reed island in Grass Lake. In the 1943–44 season

there were 75 houses almost equally distributed throughout the island; with the decline in population the following season there were 21 houses on the island, 14 in cattails and only 7 in reed cane. Such fragmentary evidence would place reed cane below marsh smartweed but above sedges in value to muskrats.

Sedges, especially *Carex r. lacustris*, had house densities, from 7.5 to 38.4 per cent lower than cattails. The value of this sedge for lodge sites was largely dependent upon its proximity to white waterlily beds.

American lotus occurred in juxtaposition to river bulrush or marsh smartweed. The density of houses in lotus at Rice and Beebe Lakes is misleading, for low water in the other plant zones necessitated the placing of most of the houses in lotus. Muskrats were still able to obtain food at adjacent river bulrush or marsh smartweed beds, and analysis of the food material showed that muskrats were travelling up to 20–30 yards to obtain food from these plants. Most of the houses in these lakes were placed along the border of the lotus zone where it joined river bulrush or marsh smartweed.

At Goose Pond, 1940–41, there were almost 200 acres of lotus in water at suitable depths, yet there was not a single house; in adjacent river bulrush beds there was 0.71 house per acre. Probably the 0.29 house per acre of lotus at Jack Lake reflects the relative value of this plant for muskrats when they must live in and feed almost entirely on it.

Wild rice had a comparatively high use for muskrat lodges at Douglass Lake. Since observations revealed that muskrats were doing most of their feeding in adjacent river bulrush, pickerelweed and even American lotus beds, it is probable that muskrats selected wild rice because of its anchorage security and the favorable water depths occurring there. Although pickerelweed, a favorite food, grew next to wild rice, not a single house was found in that zone.

Duck potato beds contained no houses at Starved Rock Pool, at Goose Pond or at Lake Chautauqua in the 1939–40 season. Water depths were deeper than optimum. The 1.77 houses per acre of duck potato recorded at Starved Rock in 1940–41, were all close to cattail beds, and analysis of food material in feeding houses revealed that most of it was obtained from cattails. Similarly at Lake Chautauqua most of the muskrats in the duck potato zone were obtaining food from nearby river bulrush or marsh smartweed beds.

Therefore, in Illinois, duck potato ranks at the bottom in value for muskrats among the marsh plants studied. Although duck potato is very nutritious, judging from the analysis made by Stearns and Goodwin (1941), the difficulty of digging up the deeply buried tubers may limit their use as food. The vegetative parts are soft and drop to the bottom early in the fall to decompose. The absence of stems above the surface gives little anchorage to houses. Stearns and Goodwin (1941) also report duck potato to be of little value for muskrats in Delaware marshes; they found that muskrats seldom constructed their houses in locations where the plant occurred and the amount utilized either for food or building material was relatively small.

Jerome Stoudt (in correspondence

1948) reports that on the Upper Mississippi Wildlife and Fish Refuge there were large areas where *Sagittaria rigida* was the only emergent, and that there were 1.8 houses per acre of that plant in the winter of 1947–48. In most of these areas he observed that muskrats constructed houses around stumps apparently for anchorage.

James Beer (in correspondence 1949) reported that in a *Sagittaria* marsh of 60 acres near Sun Prairie, Wisconsin, there were about 5 houses per acre in the winter 1948–49. Because of a paucity of other foods, *Sagittaria* must support the entire muskrat population of that marsh.

Thus, duck potato may be valuable for muskrats under certain conditions.

### OTHER FACTORS INFLUENCING MUSKRAT POPULATIONS

*Water Depth:* In any marsh vegetation the soil type and the depth of water are important in determining the "freezing out" of muskrat houses in winter. The deeper the water, the greater difficulty muskrats have in keeping their houses intact against current and wave actions. This latter factor may be especially important in vegetation such as marsh smartweed which is low, or such as American lotus and duck potato, which does not remain upright until freeze-up. Muskrats in river bottom lakes attach many houses more firmly by building them around stumps, clumps of buttonbushes, willows and the like.

Depth of water was responsible for a switch in house density between cattails and hardstem bulrush at Nippersink and Sullivan Lakes. At the former lake, cattails grew in water averaging 5 inches deep and hardstem in water averaging 14 inches; at Sullivan Lake cattails were in water averaging about 10 inches deep and hardstem bulrush in water averaging about 22 inches in depth. While over 70 per cent of the Nippersink Lake houses were frozen out, less than half of the houses at Sullivan Lake were frozen out, indicating that the greater depth prevailing there in marsh vegetation was more favorable for survival during the severe winter.

At Starved Rock Pool few houses appeared in cattail beds where the water was under 10 inches deep. The greatest density occurred at depths of 12 to 16 inches in 1940–41. In that year there was a much lower density in the duck potato zone at depths of 16 to 22 inches. In the fall of 1944, there were only a few inches of water in most of the cattail zone, forcing the muskrats to build in the duck potato zone.

No houses were found at depths less than five inches in the river bulrush beds of Goose Pond. The greatest density of houses was in depths of about 12 inches. In river bulrush beds at Douglass Lake, 1940–41, there were 2.23 houses per acre at depths of 8 to 12 inches; 1.64 houses per acre at depths 12 to 15 inches; 1.14 houses per acre at depths 15 to 20 inches; and 0.82 houses per acre in water 20 to 24 inches deep.

The lack of sufficient water in river bulrush beds at Beebe Lake, 1940–41, Fig. 1, made it necessary for practically all muskrats to build in the adjacent deeper American lotus zone. Lowest density of 0.24 houses per acre occurred in American lotus at depths of 12 to 20 inches in the main part of the lake. Where protected from severe wave

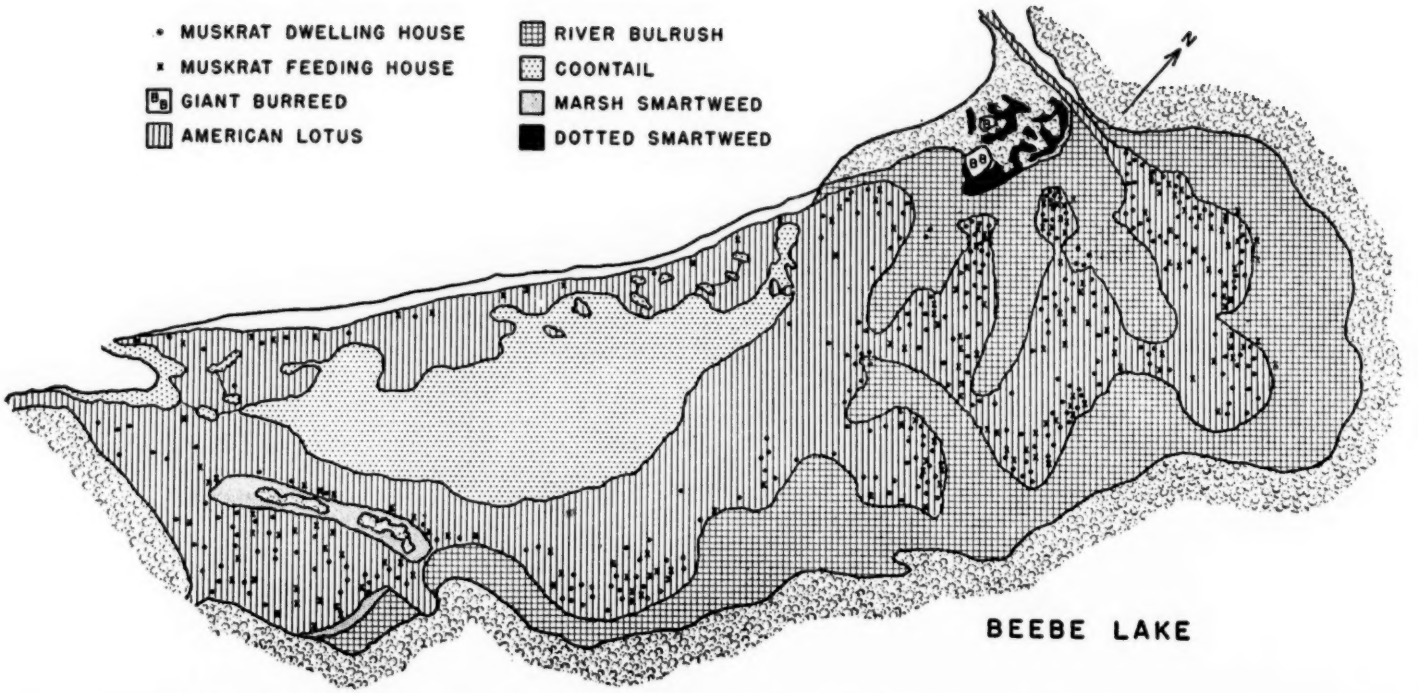


FIG. 1. Beebe Lake in the Illinois River valley, showing the distribution of muskrat dwelling and feeding houses in relation to marsh and aquatic vegetation during the winter of 1940–41. Notice the influence of "edge" on the distribution of houses.

action at the same depths in a cove, there were 0.33 house per acre. In other coves, with the water averaging only inches in depth, the house density ranged from 0.88 to 1.01 per acre depending upon the amount of river bulrush edge. The peak was reached in a five-acre, 7-inch deep pond of lotus surrounded by river bulrush where there were 15 dwelling houses, or three per acre.

At Jack Lake there were extensive marsh smartweed beds, but all out of water. Consequently there were no houses in the marsh smartweed zone but all were in the American lotus zone. There was a house density of 0.42 per acre in 6 to 9 inches of water; 0.26 per acre in water 9 to 14 inches deep; and 0.24 per acre in water 14 to 16 inches deep. None were in water over 16 inches deep.

Muskrats built houses in water up to 26 inches deep in the marsh smartweed zone of Lake Chautauqua, but only where they were protected from wave action. A 10-acre exposed marsh smartweed point in water 12 to 16 inches deep was not used by muskrats. Elsewhere houses were placed in depths of from 8 to 16 inches. Protection from wave action was afforded by black willow trees, buttonbush clumps, and stumps; these either shielded the houses or furnished foundations for them.

Bellrose and Brown (1944) stated that the optimum depth for muskrat lodge construction in the Illinois River valley ranged between 12 and 18 inches, with 6 inches about minimum and 24 inches approaching maximum. Aldous (1947) found at the Sand Lake National Wildlife Refuge in South Dakota that the optimum depth was between 16 and 30 inches, with no large houses in water less than 10 inches, and with a maximum depth of about three feet. The deeper water which muskrats sought for house building at Sand Lake may be related to the lower winter temperatures in South Dakota.

Further study has not altered our previous conclusion on water depths, but has resulted in better a understanding of optimum depths as related to the type of vegetation, the soil and the location. Thus optimum depths in American lotus and marsh smartweed are less than for cattails and bulrushes. Serious freeze-outs result when houses placed on clay or silt soils in water less than six inches deep are subject to subzero temperatures. This catastrophe may be worse at some lakes than at others depending on soil type and a severe freeze-out may change the distribution of muskrats in at least the subsequent year. Muskrats have frequently found it necessary to reside in second-choice types of vegetation because of unfavorable depths and/or soils in the most favored types.

*Water Level Fluctuations:* The fluctuation in water levels may vary from year to year and from lake to lake, and is one of the most important environmental factors affecting muskrat populations in the Illinois River valley (Bellrose and Low, 1943).

Grass, Nippersink and Sullivan Lakes in the glacial lake section of Illinois have comparatively stable water levels. Of the Illinois River Lakes, Starved Rock and Chautauqua have the most stable levels, followed by Douglass and Rice Lakes which are classified as having semi-stable levels, and Goose Pond, Goose Lake, Beebe and Jack Lakes

which are classified as having fluctuating water levels. In an earlier muskrat study in the Illinois valley, Bellrose and Brown (1941) found almost six times as many houses per acre of emergent vegetation in stable water lakes as in semi-stable ones, and twice as many per unit area in semi-stable than in fluctuating ones.

The more favorable water levels in 1940, than in 1939, probably accounted for the increase in muskrat houses at Goose Pond, where over twice as many occurred in 1940–41 as in the previous season (Table 4). At Douglass Lake, a remarkable five-fold increase in muskrat houses occurred from the 1939–40 to the 1940–41 season. A navigation dam, 25 miles downstream from Douglass Lake prevented water levels from dropping below normal there from June, 1939 through 1940. This is believed largely responsible for the tremendous increases in houses at Douglass Lake.

The water levels in the Illinois valley during 1941 were also quite stable until early October, when most of the houses had been built. Observations indicated another increase in houses at Douglass Lake, and about the same number as in the previous year at Lake Chautauqua. However, this three-year increase in muskrat numbers came to an abrupt end in early October, 1941, with a sudden five to seven foot rise in water levels. Waves demolished the floating lodges and exposed the population to severe losses (Bellrose and Low, 1943).

There was another small flood in the fall of 1943, and 15 to 25 foot floods during the spring of 1943 and 1944.

TABLE 4.—CHANGES IN NUMBER OF MUSKRAT HOUSES DURING VARIOUS TRAPPING SEASONS AT SIX ILLINOIS LAKES AND MARSHES

| Area | Number of Houses by Trapping Seasons | | | |
|---|---|---|---|---|
| | 1939–40 | 1940–41 | 1943–44 | 1944–45 |
| Grass Lake | | | 1,788 | 300 |
| Starved Rock | 292 | 301 | | 26 |
| Goose Pond | 218 | 484 | | |
| Douglass Lake | 396 | 1,554* | | |
| Rice Lake | 954 | 675 | 454 | 418 |
| Lake Chautauqua | 1,117 | 634 | | |

* Corrected figure compensating for ⅓ area not covered, 1940–1941.

Consequently, we find that the muskrat populations at Rice Lake were much lower in the 1943–44 and 1944–45 trapping seasons than in 1940–41.

From comparing muskrat house abundance for several years at lakes subject to fluctuating water levels, it is evident that this environmental condition is important in determining population density.

## RELATION OF DWELLING TO FEEDING HOUSES

The difference between dwelling and feeding houses was discussed earlier in this paper. However, the function of the feeding house is not so evident. Trappers interviewed on the matter are about equally divided in believing that it primarily furnishes a breathing hole

during freeze-up—or that it provides a secure feeding place.

Seton (1929) quotes John Rae (1888) on "eating huts" as follows: "If the pond is of considerable extent, and the house a large one containing many rats when the water begins to freeze in early winter, they keep several holes open in the ice in different directions, and at a distance from the house; and build a little hut of mud and weeds (just big enough to hold one rat comfortably) over each hole which, especially when covered with snow, prevents it from freezing. These huts enable the rats to extend their feeding grounds to all parts of the pond, which could not be reached at all, or with difficulty from the house if they had to swim home every time with a mouthful of food to eat it. With these little shelters, they are saved a great amount of labour, and are enabled to reach all the food in the pond. . . . The practice of building little eating-huts is by no means common, and does not seem to be resorted to when the pond is of moderate dimensions, and all parts of it can be reached from the house without difficulty."

Feeding houses, as we prefer to call them, do not appear to be built especially to afford feeding sites closer to preferred foods. We found that near the transition between poor and good food plants the proportion of feeding to dwelling lodges was about the same as elsewhere. For example, at Beebe Lake during the 1940–41 season, all of the houses were in American lotus, but for houses within 20 yards of river bulrush most of the food material was from that plant. Yet feeding houses were randomly distributed among the dwelling houses, with no concentration near the river bulrush edge.

There was also little correlation between dwelling house density and the relative number of feeding houses present. Table 5 shows that despite variances of 0.2 to 4.0 dwelling houses per acre in the areas below Starved Rock Pool, there was only a variation of 31.9

TABLE 5.—NUMBERS OF DWELLING AND FEEDING HOUSES

| Area | Muskrat Houses | | | Feeding Houses per 100 Dwelling Houses |
|---|---|---|---|---|
| | Dwelling | | Feeding | |
| | No. | Density per Acre | No. | |
| Nippersink Lake | 120 | 2.0 | 11 | 9.2 |
| Sullivan Lake | 95 | 0.4 | 17 | 17.5 |
| Brightland Marsh | 114 | 9.5 | 10 | 8.8 |
| Starved Rock | 301 | 2.8 | 75 | 24.6 |
| Goose Pond | 566 | 1.6 | 323 | 57.1 |
| Douglass Lake | 1,234 | 1.3 | 493 | 48.1 |
| Beebe Lake | 297 | 0.5 | 158 | 53.2 |
| Goose Lake | 81 | 0.2 | 39 | 48.1 |
| Rice Lake | 673 | 1.3 | 293 | 45.0 |
| Rice Lake | 454 | 1.4 | 145 | 31.9 |
| Rice Lake 1944–1945 | 418 | 1.0 | 150 | 35.9 |
| Lake Chautauqua | 636 | 4.0 | 348 | 54.7 |
| Jack Lake | 114 | 0.3 | 61 | 53.6 |

to 57.1 per cent in the number of feeding to dwelling houses. During three different seasons at Rice Lake, there was no correlation between dwelling house density and relative number of feeding houses.

Not only did the 2:1 ratio between house types generally occur on different lakes but also in various sections of the same lake. A small American lotus pond in a river bulrush marsh at Beebe Lake had a density of three dwelling houses per acre and yet there were 53 per cent as many feeding as dwelling houses. The over-all density there was 0.5 dwelling house per acre and 53.2 per cent as many feeding houses.

Muskrats in the glacial marshes—Nippersink, Sullivan, and Brightland Farm—did not build the same high proportion of feeding-dwelling houses as did those in the bottomland lakes of the Illinois River. This might indicate that feeding houses are built more in response to fluctuating water levels, but yet some bottomland lakes in the Illinois valley fluctuate more than others where relative numbers of the two house types were similar.

The relatively precise relationship of about half as many feeding as dwelling houses in Illinois valley bottomland lakes, leads one to ponder the behavior pattern responsible for this arrangement. Could it be that only adult muskrats build feeding houses?

## SUMMARY

1. A study of the plant food preferences of Illinois muskrats was made by comparing the proportion of plant food material found in the "feeding" house in mid-winter with the late-summer availability of plants within the feeding radius of the houses.

2. Although there was a great deal of individual variation, it was evident that muskrats selected certain plants and certain parts of plants for food.

3. Muskrat houses were deemed an index to the relative muskrat population density in the Illinois marshes studied.

4. The muskrat plant food preferences, and the relative over-all population value of various plant types in Illinois for muskrats are listed in descending order of importance.

*Food Preference*

1. Cattails
2. Pickerelweed
3. Hard and softstem bulrush
4. River bulrush
5. Marsh smartweed
6. White waterlily
7. Sedges
8. American lotus
9. Black willow
10. Duck potato
11. Reed cane
12. Wild rice
13. Water milfoil
14. Coontail

*Population Value*

1. River Bulrush
2. Cattails
3. Marsh smartweed
4. Hardstem bulrush
5. Reed cane
6. Sedges
7. American lotus
8. Wild rice
9. Duck potato

5. Water depth was a factor affecting muskrat house density in different marsh plant types. Optimum depths varied with the type of vegetation and the exposure to wave action and probably with the bottom soil type.

6. Fluctuating water levels adversely affected muskrat populations, thereby lowering the value of river bulrush and marsh smartweed; these plants are so abundant as to characterize Illinois River bottomland marshes.

7. Feeding houses do not appear to

be built nearer than dwelling houses to choice feeding beds; they are more or less randomly distributed among the dwelling houses. We may well speculate on the relationship of about half as many feeding as dwelling houses in Illinois valley bottomland lakes. Was environment or composition of the population responsible for differences in proportion of house types in glacial lake and river bottom marshes?

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# SPREADING TENDENCIES OF MULTIFLORA ROSE IN THE SOUTHEAST[1]

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The use of multiflora rose (*Rosa multiflora*) as a living fence and as wildlife cover is being widely recommended for farms in the Midwest and Northeast. Trials of the plant in these areas indicate only limited tendencies to spread, and there appears to be little danger of the species becoming a nuisance.

In the spring of 1947 work was initiated in the Southeast to determine the adaptability of multiflora to the climate, soils, and agricultural program of this region. Several years of growth will be required on recent plantings before such characteristics as that of spreading can be evaluated. Hence an effort has been made to locate old plantings and to study what has happened to them.

This is a matter of immediate concern in the introduction of a new plant. Coastal Plain and Black Belt farmers have had one unfortunate experience with a rose introduced from China. "Cherokee" rose (*R. laevigata*), has be-

[1] This paper is a contribution from the Patuxent Research Refuge of the Branch of Wildlife Research. The study was a part of the Service program of wildlife investigations on agricultural lands under the supervision of Durward L. Allen. Helpful suggestions and other favors were contributed by Verne E. Davison, Regional Biologist, and other personnel of the Soil Conservation Service.

come a pest locally in pastures, woodlands, and idle areas. In one manner or another it has been distributed from North Carolina to Florida and Texas. If multiflora rose behaves similarly in the southern states, its use will need to be restricted.

## STUDY AREAS AND METHODS

In the Southeast, topography ranges from nearly level land to steep mountain sides. There is a wide variety of soil types. Sands predominate in the Coastal Plain, and either black, red, or yellow clays are found further inland. Rainfall averages 55 inches and intensity of fall is great. Most farms have an abundance of cover. The only exceptions are a strip of the Lower Coastal Plain near the gulf and a portion of the Black Belt which is in grazing land. On these farms multiflora might be useful for wildlife cover as well as for fencing.

Three plantings were found suitable for study, two in Alabama and one in Georgia. One Alabama planting is on the nursery of Herbert M. Norwood on highway US 11 near Trussville. The other is on the Pearl and Zennie Allen farm in Sec. 7, T-11, R-8, in the Ball Play Community, 12 miles northeast of Gadsden. The Georgia planting is a part of an early SCS highway erosion-control project along US 29 from Athens to Danielsville, and Georgia State Highway 72 from Athens to Comer.

Each of these plantings was studied to determine the extent to which it had become established on surrounding land. Because spreading was irregular and covered a large acreage, the technique adopted was to traverse thoroughly on foot, within a radius of 2 miles from the original stand, all roadways, hedgerows, field edges, fences, drainageways, open fields, woodlands, pastures and idle areas.

On a 6-acre field on the Griffith farm, adjoining the city of Danielsville, plants were growing throughout 4 acres. Here invasion from the highway into the field was studied by the use of quadrats.

## IDENTIFICATION

Multiflora is easily identified in the field. The shrubs grow up to 10 feet in height, and from a distance the small white or pinkish-white flowers resemble blooms of the blackberry (*Rubus* spp.). The plant is deciduous. Leaves appear early in the spring, and blooms are found during the months of April and May. It can be separated from other rose species by two characteristics: styles are exserted and the stipules are pectinate; thorns are curved, flattened and mostly paired. Flowers occur in pyramidal corymbs with an entire stem usually in bloom.

Fruit persists on the plant from September to May. Thornless varieties of multiflora rose are not uncommon. Variations also occur in the date of flowering and fruiting, height, color of stem and leaf, and in the location of the thorns. Identifications of plants from each of the locations were verified by the Bureau of Plant Industry, Beltsville, Maryland.

## ALABAMA PLANTINGS

On the Norwood nursery multiflora rose was established by accident. In 1928 hybrid tea-roses were grafted on multiflora rootstock and set out in rows. This is a common horticultural practice. The grafts did not "take" but

the stocks grew and were allowed to remain. The original planting covered approximately 3 acres, and now it is possible to see the old plants still growing in nursery rows as well as plants that have spread to other parts of the field.

Most of this nursery has the appearance of abandoned land. The field in which the old multiflora is growing has not been cultivated in 10 years. In one portion of it volunteer pines are 12 to 15 feet high. The largest mature multiflora plants, 8 feet tall, are growing both in the open and with the pines. Young plants can be found readily, indicating that invasion is still progressing.

From these original plants, spreading has been confined for the most part within a radius of a quarter-mile. Here plants are well distributed over the nursery at 50–200 per acre. However, two rose plants were found under a tree a mile away.

On the nursery, multiflora is growing in a variety of plant communities. There were roses in a loblolly pine planting approximately 15 years old, in stands of hardwoods and in mixed stands of pines and hardwoods. Here plants showed the effects of competition from the trees, as was evidenced by spindly stems and light fruiting.

Cultivation now is confined to a few fields of the nursery and in these no roses were found. The only soil disturbance in other fields occurs when a mature shrub is removed for transplanting. In these locations native herbaceous vegetation has volunteered and succession is progressing as on idle land. It is evident that in uncultivated areas multiflora rose propagates successfully.

On the Allen farm near Gadsden, multiflora rose has spread from one plant. It was set in 1909 on what was then a school yard. A local resident who attended this school in 1914 remembers it as a mature bush. This original plant is still growing. The school yard has been abandoned since the building burned in 1930, and a partial stand of loblolly pines is growing there. This type of forest cover continues westward on a strip of wet land for 1,100 feet, and eastward a more dense stand of trees extends for 1,000 feet. On both sides of this drainageway there are cultivated fields.

Multiflora has spread over approximately 10 acres. Invasion has been confined to three directions. The sides of the drainageway east and west of the school property support about equal numbers of plants. No shrubs were found in a cultivated field to the south. To the north, multiflora is growing on wet soil in the bottom of the drainageway, but establishment has not been as successful as on the sides of the drain. The estimated number of roses over the 10 acres ranges from 10–100 plants per acre. Spreading is still progressing, as is evident from the small stems which are competing with native vegetation.

Many single rose plants were found in an unimproved pasture on another drainageway 1,500 feet north, and also along the road ditches out to a distance of 3,300 feet.

### GEORGIA PLANTING

Three species of roses were used for highway erosion control by the SCS in 1935–36. They were *Rosa maretti*, *R. odorata* and *R. multiflora*. Planting stock was mixed before distribution, so

it is not known whether all three of these species were set on US 29 and state highway 72. In the present study specimens were taken from many plants and all were identified as multiflora. Evidently the other two species had died out, were overlooked, or had been planted elsewhere.

A cursory examination was made of most of the fields along the highway. There is evidence of spreading along each road. Multiflora is growing in ditches and can be found along the streams. Spreading is not confined to the drainageways; roses are growing along hedgerows, under trees and shrubs and from brushpiles and thickets of vines.

A detailed survey was made of the Griffith farm which is adjacent to Danielsville on the south. This farm lies on the north side of a creek which is a branch of Broad River. Highway US 29 crosses the stream and bisects the farm. Multiflora was planted on the backslopes above the creek bottom to the top of the hill which is within the city limits of Danielsville.

Invasion has been greater on this farm than anywhere else along these highways. Roses were growing in a 1,200-foot radius from the original planting at an estimated density of 50–300 stems per acre. Within this radius is the Griffith farm, part of the city of Danielsville, and other adjoining land.

Spreading has been in all directions. In Danielsville multiflora is growing on vacant lots, beside fences and in ditches and yards. Observations indicate more roses growing at elevations lower than the original planting than at higher ones. Shrubs are thriving along hedgerows and fencerows, in the highway road ditch, on terraces and drainageways and along the creek bottom. Many plants were found from the bridge 1,000 feet downstream. One was located 2,300 feet below the crossing. On the uplands, roses were not growing in fields which have been kept in cultivation.

Spreading is spotty in all plant communities. In hedgerows and woodlands, stems numbering from a few to as many as 50 were found under some trees. Most of these were small with succulent growth from a few to 20 inches in length.

The field where the quadrat study was conducted has not been tilled in the past 10 years. In the line of quadrats nearest the highway, invasion was at the rate of 254 plants per acre, while in the second line the density was 145 plants per acre. These figures reveal continuing migration into the field. Most of the mature plants in this field had become established in old terrace channels or drainageways. This would suggest that seeds were transported by water. Ecesis now is progressing between terraces in a ground cover of sedge and annual lespedeza. Runways in this field denote a high small-mammal population, which suggests that they might be a factor in seed dispersal.

## DISCUSSION

In the Southeast many factors seem to influence the spreading of multiflora. A favorable climate permits it to grow rapidly and fruit heavily. The plant will grow in a wide variety of soil types, but like all roses, it thrives best on clay soils rather than on sand. Most soils in the Southeast are clays, and observations indicate that multiflora will survive well

wherever there is moderate fertility.

Seeds are distributed by water and birds. They are dispersed in run-off water when there is not sufficient cover on the soil. It may be significant that seedlings of rose have appeared under trees, shrubs, and fences and in hedgerows and thickets. These sites are bird roosts. Rose hips are available all winter and are eaten by a variety of species, which probably means that the seed is given fairly wide distribution. It appears that most of these seedlings die during the first summer.

Multiflora rose has not spread in land under agricultural use, where the soil is disturbed regularly or forage is heavily grazed. It has appeared near old plantings in fields that have been idle for a period of years or where it sprouted in thickets out of reach of cattle. It does not compete well in forested areas. As trees increase in size, roses become spindly and fruiting is light. Eventually it probably is shaded out in dense stands. In row-crop fields the annual turning of the soil and cultivation in spring and summer destroys the seedlings.

From these observations it appears that some control of the shrub by herbicides or other means may be desirable where it is used as wildlife cover or for other purposes near idle lands. Thus the possibility of spreading might be a limitation to its use in some quail management areas.

Observations thus far indicate the need for caution, but they should not preclude the continued testing of multiflora rose as a living fence on agricultural lands or as a cover plant in areas less intensively used. Much more needs to be learned of the positive values of this plant.

## SUMMARY

In 1948–49 studies were made on the spreading of multiflora rose at the sites of three old plantings in Alabama and Georgia. The age of these plantings varied from 14–40 years. Roses were invading surrounding land at each site.

Observations indicated that seeds are carried by water and birds. Seedlings were numerous in drainageways leading from old shrubs. Birds had deposited seed under trees, in thickets, and along hedgerows. Seedlings growing under a single tree varied in number from a few to 50. Two rose bushes were found under a tree a mile from the probable point of origin.

Seedlings were spreading in unimproved pastures by growing in thickets where they were protected from grazing and mowing. Plants were not found in cultivated fields.

Spreading was similar near all three locations in like plant communities. Competition from trees affected multiflora more than that of any other type of vegetation. Plants thrive in pine woodlands with an open canopy, but growth is weak in a thick hardwood stand. Control will be necessary if multiflora rose is to be kept from spreading in idle land and unimproved pastures.

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# A MODIFICATION OF THE ELECTRIC FISH SHOCKER FOR LAKE WORK

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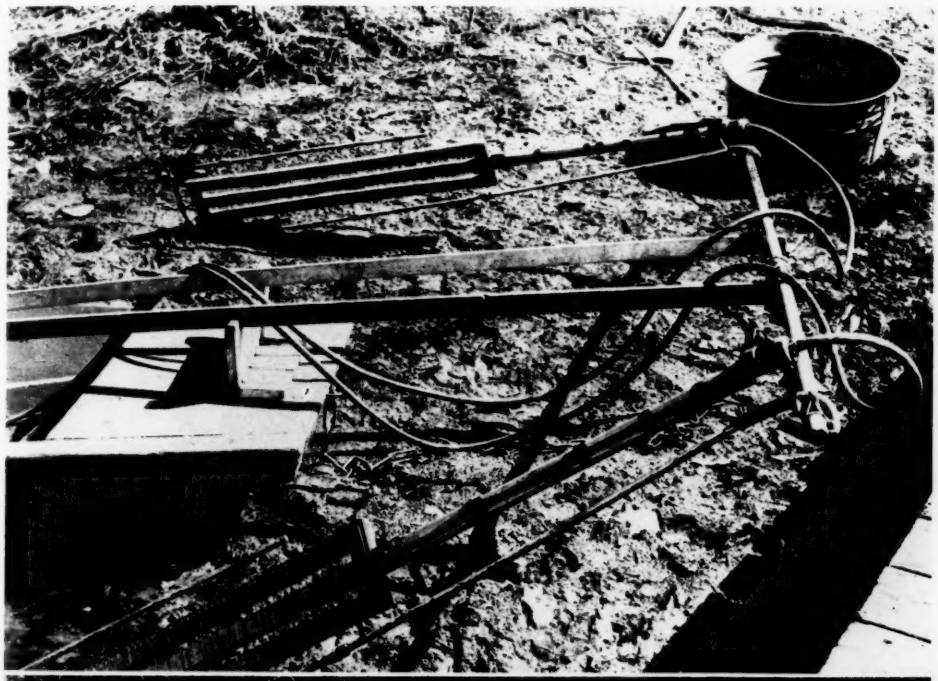
The use of an electric current for stunning fish was demonstrated almost two decades ago in Europe (Hager, 1934), but only during the past ten years have American biologists developed the "shocker" for their particular needs. This device has been used principally in population studies of small streams, especially the trout streams of northern and north-eastern United States. In Illinois and other states throughout the mid-west and south, artificial impoundments support an important part of the sport fishery. Securing live specimens for food habit studies or marking, from the shallow weed or stump-filled waters of these areas, presents a difficult problem.

A search for an efficient collecting method led us to modify the fish shocker for use from a rowboat. This development of the electric shocker provides a labor-saving means of sampling lake populations in areas where seining and wading are impossible.

An old abandoned strip-mine, lying in the flood plain of the Middle Fork River in east-central Illinois and supporting a large and varied fish population, has been the principal site for testing the rowboat shocker. When strip-mining for coal was discontinued in this area and the deep channels between spoil banks filled with water, a private fishing club purchased the mine properties. Flood water from the Middle Fork has reduced the acid from mine waste and introduced a variety of fishes; the water area now consists of many small ponds connected by narrow channels. Banks are steep mounds of shale and top-soil that were thrown up as the shallow coal bed was uncovered and taken from the ground. Dense brush now covers the ridges, with stumps and dead trees lining the edge of the water. This unusual habitat has provided exceptionally good fishing for the sportsmen and at the same time has furnished an interesting area for biological investigations.

Collections of fish were difficult to obtain from the stump-filled pools and irregular channels of this flooded strip-mine. Seining these waters was impossible because of the dense brush along the shore and the steep slope of the bank. Hoop-netting seemed to be the only feasible method of securing samples; but, since it was practical to lift the nets only once a day, the specimens were of limited value for use in food habit studies. Stunning the fish with an electric shocker would provide live specimens suitable for stomach analyses. An electric shocker was tried, using the same apparatus as has been developed for shallow stream work, but the irregular bottom of the old strip-mine made wading with the separate electrodes impossible. In an attempt to overcome the difficulties of having to wade and carry the electrodes, we tried to hold them on either side of the boat's bow and at the same time pick up the stunned fish with dip nets. This incon-



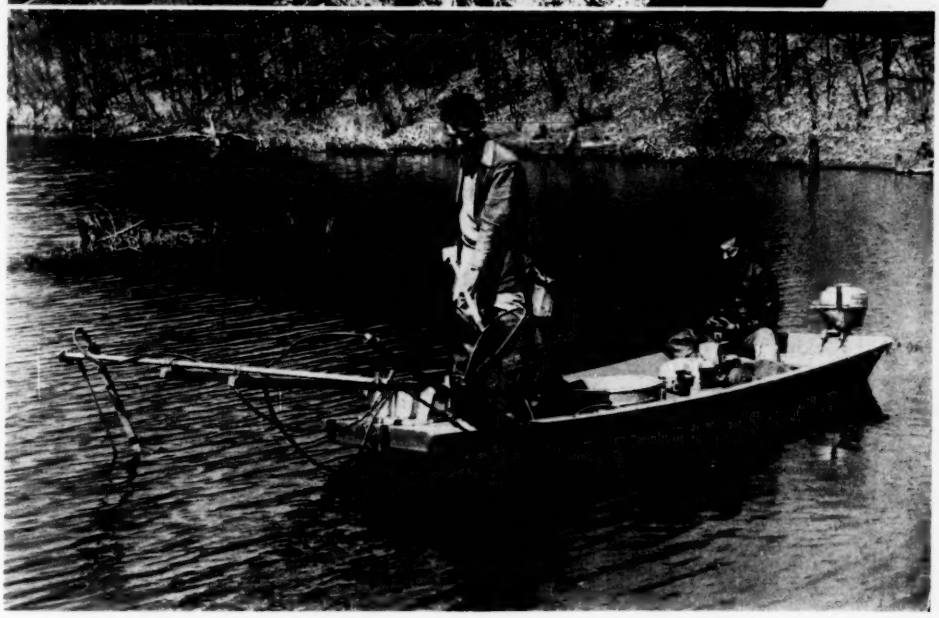


PLATE 9. *Above:* Supporting framework and electrodes assembly for boat-operated fish shocker. Cables from the electrodes are joined into a single cable which is plugged into the generator outlet. Iron rods protecting and supporting the electrodes are insulated with rubber tubing at points of attachment with other parts of the assembly.

*Below:* Working the fish shocker from a boat is a two-man operation. A man standing in the bow of the boat manipulates the electrode assembly and dips up fish as they are stunned; another in the stern operates the generator and keeps the boat in position and moving at a desirable rate of speed.

venient arrangement was not satisfactory until an out-rigging was developed to support the electrodes in the desired position.

All the equipment for operating the shocker is carried in a 14-foot, flat-bottomed skiff (see Plate 9). Although other types of boats might be used, it is very important that the boat be steady and easy to maneuver. The boat is powered by a 5-h.p. outboard motor which, when fish are being collected, is operated at a slow trolling speed. Since the amount of charge a fish receives is directly proportional to the time of exposure, efficient operation requires that the electrical field move past a fish rather slowly; a speed of about thirty feet per minute seems to produce a maximum number of stunned fish for collecting. A year of testing has shown that the speed of operation is associated somewhat with water temperatures. This shocker has been used very successfully through thin ice, but work in cold water requires a further reduction in speed. Shocking at low water temperatures is favorable for two reasons: the sluggishness of the fish keeps them from avoiding the electrical field, and at the same time, the individuals remain stunned for a longer period, allowing more time for netting and often floating to the surface before again becoming active.

Electric current is produced by a portable, 115–230 volt, gasoline-driven generator which is carried in the mid-section of the boat. One hundred and fifteen volts is sufficient to stun fish, but the 230-volt current gives a larger electrical field and is thus more effective in deep water. This higher voltage develops independent cylindrical fields around each electrode; each field draws 11 amperes, or a combined amperage of 22. Very little scalding of the fish has been observed even while using the higher voltage. Only alternating current has been used with this rowboat shocker. Although both direct current and undulating current have been used successfully by biologists, it is doubtful if either would be of advantage with this fish shocker. Alternating current has a slight tetanizing effect on the fish and the sudden movement of the victim thus helps attract the collector. And, too, many of the fish which are chased from their hiding places will rise to the surface of the water—as mentioned previously, this is particularly true in cold water when the fish remain stunned for a longer time.

A two-strand number twelve rubber insulated cable carries the electric current from the generator to the electrodes (Plate 9). For the 230-volt current the generator outlet requires a three-pronged male plug; the ground wire is left dead and the two hot wires are connected to the two strands of the lead cord. From the generator the lead cord extends forward ten feet where it branches to send one hot wire to each electrode. The branch wires are each ten feet long, ending in male plugs which attach to complementary plugs at the upper ends of the electrode handles.

An elongated type of electrode, as was described by Shetter (1947) for Michigan streams, seems to be best for work in lakes. This electrode consists of a 36×6-inch frame of light 1×2-inch wood and wound with #16 copper or phosphor-bronze wire, the coils being spaced one inch apart (Plate 9). A two-

foot handle extends upward from the rectangular frame and supports a single strand, insulated cord ending in a plug to which is attached the plug and lead wire from the generator.

Each electrode is mounted in a frame of $\frac{3}{8}$ inch iron rod (Plate 9). This form extends around the electrode and upward somewhat beyond the end of the handle, there terminating in an "eye" which is insulated with rubber tubing. The horizontal iron pipe which supports the two electrodes extends through the "eyes" made at either end of these iron frames, and thus the electrodes swing freely on the supporting pipe. The "eyes" of the electrodes are prevented from slipping off the ends of the pipe by loops of tightly stretched innertubing. This loose suspension of the electrodes allows them to be pushed up when contacting an obstacle or when operating in shallow water. The surrounding iron frame-work serves to sink the wooden parts, causing the electrodes to hang vertically in the water (Plate 9, below, left) and at the same time protects the coils from snags.

The rigging developed to support the pipe and two electrodes consists of a pair of 2×2-inch light weight wood shafts eight feet long, bolted together at the inboard end and spread over the bow to form a narrow angle. At the forward ends of the shafts, eye-bolts hold the 8-foot pipe.

Various adaptations may be necessary to attach this rig to different boats. Boats which are square across the front may have a low yolk-like piece secured to the bow; the spread arms of the frame rest across this support. At the inboard end, the frame is fastened to the bottom of the boat by means of an eye-screw and stout cord. The advantages of this arrangement (over that of having the frame bolted or nailed to the boat) is that the framework may be pushed back or forward or to either side in case an obstruction is encountered. Likewise, the entire frame and electrodes may be lifted above the water if one should find this necessary.

Operation of the rowboat shocker requires two men—one in the bow of the boat to collect stunned fish and to manage the electrodes, the other at the stern to operate the outboard motor. The man at the rear may dip up an occasional specimen but most of his attention should be given to handling the boat and to cutting the electricity in emergencies. Although both electrodes swing independently and will ride over stumps and adjust to shallow water, at times it is necessary to lift one electrode away from a snag. The man in the bow of the boat may do this by hooking his dip net under the short end of the iron guard around the electrode and raising the entire unit free of the obstruction. When backing out of shallow water, it is desirable to lift the electrodes out of the water and rest their lower ends on the bow of the boat, rather than have them pushed into the mud as they are dragged backwards.

Several distinct advantages and disadvantages may be listed for this arrangement of the electric fish shocker. A primary benefit is its use in collecting along rip-rapped or rough, steeply sloping banks. In this situation, one electrode may ride along the shallows while the other hangs straight down into the deep water. As the electrical field is moved along the bank, the fish hiding near the shore or between rocks

are shocked and a high percentage of them are readily collected. Certain limitations of the shocker make it impractical for use generally. In very soft waters, the effective electrical field is greatly reduced, and fish are stunned only near the electrodes. Turbid waters conceal stunned fish and make collecting difficult or impossible. Some species of fish tend to move ahead of the boat, due to the vibrations of the generator, while others hide in protective cover and are stunned. Those that keep moving may be stunned only if driven into blind channels or bays where they reverse direction and attempt to escape through the electrical field.

Even though a considerable number of fish may move away from the electrical field and others may be stunned below the depth of visibility, this modification of the fish shocker requires less work, is faster, is less selective, secures fresher specimens, and may be used in more situations than most other equipment for sampling fish populations.

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# SEX AND AGE RATIOS IN WISCONSIN MUSKRATS[1]

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During the past few years there have been published at least 22 papers dealing to some degree with sex ratios of muskrats. These papers have established that there is usually an excess of males taken during the fall, winter, and spring trapping seasons. There is a smaller backlog of data on age ratios. Some of these data have been used successfully in analyzing population mechanisms in natural populations (Errington, 1943).

This paper presents sex and age data from 24,082 fall and early winter trapped muskrats and sex data from 1,149 nestlings examined in southern and central Wisconsin from 1946 through 1948 and reviews the data in the literature.

## METHODS

Most of the sex and age ratio data were based on the examination of pelts after they had been dried. The sex de-

[1] This study was conducted jointly by the University of Wisconsin and the Pittman-Robertson Division of the Wisconsin Conservation Department.

termination was based on the presence or absence of teat marks on the flesh side of the pelt (Buss, 1941) and aged by the molt pattern method (Shanks, 1948). Sex and age data on animals in the flesh were obtained by examining the gonads (Errington, 1949) and the external genitalia (Baumgartner and Bellrose, 1943). Nestlings were sexed by examination of the external genitalia and by palpating for the penis (Dozier, 1942).

## SEX RATIOS

The data from the literature indicate that the sex ratios in muskrats trapped during fall, winter, and early spring are usually unbalanced in favor of the males. The ratio based on 89,540 muskrats reported in the literature from many localities, is 125 males per 100 females (55.6% males). Only four of the 33 population samples recorded in the literature showed the sex ratio unbalanced in favor of the females, while 29 showed the sex ratio unbalanced in favor of the males, four to the extent of over 200 males per 100 females.

This analysis, assuming that there is a primary sex ratio of 100 males per 100 females, suggests that there is a mortality factor working against the females at some stage in the life cycle, but it does not indicate at what season this mortality occurs or in what age class it operates. Several authors (Lay, 1942; Hewitt, 1942; Marshall, 1937; and Johnson, 1925) believe that there is some seasonal variation in the relative ease with which the sexes can be trapped, but the evidence is not conclusive.

Marshall (1937), in Utah, found a decided shift from 95 males per 100 females (48.0% males) for 1,065 animals caught in the fall to 211 males per 100 females (68.5% males) for 491 caught in late March and early April. Hewitt (1942) in Ontario, on the other hand, found that from March 8 to 26 there were 135 males per 100 females (57.4% males) in the catch 6,146, while from March 27 to April 2 there were 92 males per 100 females (47.9% males) in the 1,669 animals handled. In Wisconsin such discrepancies in the ratios of animals taken during the fall and winter were not found by the authors.

Dozier *et al.* (1948) examined 23,511 muskrats over a five year period. These animals were taken between January 1 and March 15 and there was no indication of a differential in the ease of trapping the two sexes between late winter and early spring.

The samples from Utah and Ontario compare ratios before and after the beginning of the breeding season while the Maryland samples (Dozier *et al.*, 1948) were apparently taken before the beginning of the breeding season (Forbes and Enders, 1940 and Enders, 1939). If there were selectivity for one sex in muskrats trapped in fall or winter the catch early in the season should be greater for this sex, while during the latter part of the season after the selected sex had been reduced in numbers the other should predominate. By this reasoning such a picture should show up best if the population were heavily trapped. There is no indication of this in the sample from Maryland (Dozier *et al.*, 1948) or from the data presented here.

Live trapping on three small marshes near Madison, Wisconsin has indicated that there is a difference in the habits

of the two sexes during the breeding season which is not apparent during the fall and winter. Of 69 captures in live traps during the fall and winter, 39 (56.5%) were males, while of the 83 adult captures in the breeding season 60 (72.3%) were males. During the fall and winter the females were captured an average of 2.1 times and the males 2.2 times each. In contrast during the breeding season the females were captured an average of 1.8 times, the males an average of 7.5 times each.

Based on the live trapping data, fall and early winter sex ratios to be discussed later in this paper, and sex ratios reported by several authors from the various seasons, it is believed that the sex ratios obtained from muskrats trapped in fall and early winter are representative of those found in the actual population for the northern areas. It is possible that the southern areas, such as along the gulf coast where there is no definite seasonal anestrous period (Svihla and Svihla, 1931) may not show the same picture as the northern areas.

*Sex ratios for different age classes.* The data given by Errington (1939), McCann (1944), Shanks (1948), and Sooter (1943) indicate that the adult sex ratio is different from that of the immature animals. The sex ratios in the adults were in favor of the females while in the immatures they were definitely in favor of the males. The only reference to sex ratios in nestling muskrats is that of Errington (1939), who found a sex ratio of 120 males per 100 females (54.5% males) for 930 nestling muskrats from Iowa.

No data on sex ratios of embryos have been found in the literature. Thus it is impossible to say definitely what the ratio is at this early stage of development.

*Wisconsin sex ratios.* During the summers of 1946, 1947, and 1948, 1,149 nestlings were examined from the Horicon Marsh Wildlife area and from marshes in the vicinity of Madison in Wisconsin. These include the nestlings examined by Harold Mathiak on the Horicon Marsh in 1948. These were found to have a sex ratio of 121 males per 100 females (54.7% males) which was nearly identical with the 120 males per 100 females found by Errington (1939). Inspection of the data showed that there was a difference in the sex ratio between the small and large

TABLE 1.—SEX RATIOS OF WISCONSIN MUSKRATS BY AGE CLASSES

| Class | Sample Size | ♂♂ | ♀♀ | ♂♂ per 100 ♀♀ | Per Cent ♂♂ | Sampling* Limits of Per Cent |
|---|---|---|---|---|---|---|
| Nestlings under 100 gm. in wt. | 820 | 438 | 382 | 114 | 53.4 | ±2.8% |
| Nestlings over 100 gm. in wt. | 329 | 192 | 137 | 140 | 58.3 | ±4.5% |
| Fall immatures | 18,832 | 10,784 | 8,048 | 134 | 57.3 | ±0.3% |
| Fall adults | 5,250 | 2,599 | 2,651 | 98 | 49.5 | ±1.1% |
| Total | 25,231 | | | | | |

* Sampling limits at the 0.05 probability level.

nestlings, with the highest proportion of males being found in the older groups. The data were accordingly broken down into two groups: those weighing less than 100 grams and those weighing over 100 grams (see Table 1). This has been suggested by Mathiak (1948) in his report on the 1948 portion of the Horicon Marsh data.

When statistically analyzed at the 0.05 probability level the sex ratio difference between the small nestlings and the fall-caught immatures is significant, but there was no evidence that the sex ratio found in the older nestlings and fall-caught immatures was different. The fall-caught immatures and fall-caught adults had sex ratios which are significantly different.

It was suggested by Mathiak (1948) that there might be a difference in the sex ratios of the young born in different periods in the breeding season. In order to check this, the data were broken down into four two-week periods (see Table 2). While there is considerable variation in the sex ratios between the various samples, there is no statistical evidence that these four groups were taken from populations with different sex ratios. When each year's data were broken down separately, individual groupings became too small for drawing definite conclusions.

These data indicate that there is a shift with age in sex ratio in the nestlings towards an unbalance in favor of the males but that the period of birth did not have an apparent effect on the sex ratio. There is also a shift from an unbalanced ratio in favor of the males in the fall-caught immature muskrats to one approximately even or slightly unbalanced in favor of the females in the fall-caught adults (see Table 1). A similar situation has been demonstrated by Laurie (1946) in three of four populations of the house mouse (*Mus musculus*) examined by him wherein the sex ratio shifts with age. The nestling mice were unbalanced in favor of the females with a shift favoring the males in the immature animals followed by a reversal favoring the females in the adult segment of the population. Observations do not indicate why there should be a shift in sex ratio of the nestlings, but there are some indications as to the mechanism of the reversal to a ratio favoring the females in the adult segment of the population. Live trapping during the breeding season showed that the males were caught about three times as often as the females. This suggests

TABLE 2.—MUSKRAT NESTLING SEX RATIOS BY PERIOD FROM 1946, 1947, 1948, IN WISCONSIN

| | ♂♂ | ♀♀ | ♂♂ per 100 ♀♀ | Per Cent ♂♂ | Sampling* Limits of Per Cent |
|---|---|---|---|---|---|
| May 1–15 | 65 | 61 | 107 | 51.6 | ±7.3% |
| May 16–31 | 265 | 192 | 138 | 58.0 | ±3.8% |
| June 1–15 | 122 | 118 | 103 | 50.8 | ±5.3% |
| June 16–30 | 178 | 147 | 121 | 54.8 | ±4.5% |
| Total | 630 | 518 | 121 | | |

* Sampling limits at the 0.05 probability level.

that the males move about much more and probably range farther than do the females, which makes the males more vulnerable to predation and accidents as well as to trapping. Also, the males seem to be more intolerant of others of their own sex than do the females and fight much more during this season. It is much more common to find adult males with serious wounds from fighting than adult females during the spring and summer. There is very little sign of fighting from the latter part of September through the winter unless environmental conditions cause extreme crowding of the population.

Our observations indicate that fighting among males is probably one of the most important factors in the selective mortality that occurs. Predation and accidents are also probably selective against the males.

## AGE RATIOS

Age ratios have been recorded for muskrats by Errington (1943), Shanks (1948), McCann (1941), Sooter (1943), and Baumgartner and Bellrose (1943). With the exception of Errington, these authors were unable to gather enough data over a sufficiently long period of time to use them for interpreting population phenomena. Errington (1940) has pointed out that as the population density increases the ratio of young to adults is reduced in the fall population. In other words, the production and survival of young is in inverse relationship to the density of the breeding population.

*Litter size.* Warwick (1940) and Ulbrich (1930) found that the average number of embryos from 119 pregnant females examined in the British Isles and Germany was 7.0. This agrees with our observations on litter size based on counts of complete litters found in the nest. In 1946, 1947, and 1948, 15, 17, and 44 litters which were considered to be complete were examined giving average litter sizes of 6.3, 6.8, and 8.0 respectively. In examining 539 adult females for placental scars in 1946 and 1947, we found 518 had borne young and that 21 or only 3.9% were barren. It is probable that the average of 15.5 placental scars found per breeding female is fairly close to the average number of young born to each breeding female since most adult females bear two litters during the breeding season in Wisconsin (unpub. data).

*Fall age ratios.* Age ratio data were obtained from 24,082 muskrats during the fall and early winter of 1946, 1947, and 1948. These data came from 17 different muskrat areas in Wisconsin. The bulk of these areas are marshes with varying degrees of level ditching, besides having various water supply, water depth and vegetative types. At the present time it is not possible to analyze the effect of these different environmental conditions. The age ratios in these marshes varied from 191 young per 100 adults to 673 young per 100 adults with an average ratio for this three year period of 362 young per 100 adults or 7.23 young per adult female (see Table 3). They also show that there is a tendency for the low age ratios (few young) to come after years of light trapping and the high age ratios (many young) to follow years of heavy trapping pressure. This agrees with Errington's (1943) observations.

## DISCUSSION

For the proper application of age and sex ratio data to population mecha-

nisms, one should have an accurate estimate of the density of the breeding population. Since it was not possible to obtain these data it is necessary to set up a relative population index. The best index available seems to be the number of muskrats taken per acre the previous year. The assumption is made that on marshes with similar environmental conditions that the greater the take per acre from the area the less dense the breeding stock will be the following year. Ingress and egress apparently do not affect the breeding density as live-trapping and tagging indicate that movement is not excessive unless adverse habitat conditions prevail.

In 1945 only one muskrat was taken per four acres on the Horicon Marsh Wildlife Area. While tularemia and Errington's disease were plainly evident through the winter and early spring, the actual loss from the marsh was not great enough to deplete the breeding stock. In 1946, 2.65 muskrats were taken per acre with an age ratio of 227 young per 100 adults or 4.2 young per adult female. In 1947, 2.27 muskrats were taken per acre, and the age ratio reflects the moderate harvest of the previous year by rising to 412 young per 100 adults. In 1948 about 5.5 muskrats were taken per acre with an age ratio of 379 young per 100 adults. This age ratio is slightly lower than in the previous year and the take per acre for the previous year (1947) was also lower than it was in 1946.

TABLE 3.—DATA ON SEX AND AGE RATIOS AND TAKE ON SOME SOUTH AND CENTRAL WISCONSIN MARSHES BY MARSHES AND YEAR

| Area | Year | Total Sample | Total Catch | Acres | Catch per Acre | Yg. per 100 ad | Yg./ad. ♀ | ♂♂ per 100 ♀♀ | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Adult Population | Imm. Population | Total |
| Horicon | 1945 | — | 1,016 | 4,000 | 0.25 | — | — | — | — | — |
| Horicon | 1946 | 4,467 | 8,346 | 3,150 | 2.65 | 227 | 4.18 | 83 | 124 | 110 |
| Horicon | 1947 | 4,755 | 9,535 | 4,200 | 2.27 | 412 | 8.12 | 97 | 126 | 120 |
| Horicon | 1948 | 8,133 | 24,631 | 4,500 | 5.47 | 379 | 7.84 | 106 | 128 | 123 |
| Terrill's Marsh | 1945 | — | 1,167 | 320 | 3.65 | — | — | — | — | — |
| Terrill's Marsh | 1946 | 1,366 | 1,385 | 320 | 4.33 | 566 | 12.10 | 113 | 150 | 144 |
| Terrill's Marsh | 1947 | 996 | 998 | 320 | 3.12 | 598 | 14.23 | 138 | 158 | 155 |
| Terrill's Marsh | 1948 | 269 | 300 | 320 | 0.94 | 627 | 11.60 | 85 | 149 | 138 |
| Winnebago Co. #1 | 1946 | — | ±800 | 50 | 16.00 | — | — | — | — | — |
| Winnebago Co. #1 | 1947 | 347 | 347 | 50 | 6.94 | 554 | 10.50 | 89 | 172 | 155 |
| Winnebago Co. #1 | 1948 | 100 | 103 | 50 | 2.06 | 400 | 7.27 | 82 | 116 | 108 |
| Winnebago Co. #2 | 1946 | — | 380 | 340 | 1.12 | — | — | — | — | — |
| Winnebago Co. #2 | 1947 | 96 | — | 340 | — | 209 | 3.82 | 82 | 132 | 113 |
| Winnebago Co. #2 | 1948 | 393 | 394 | 340 | 1.16 | 212 | 4.24 | 100 | 117 | 111 |
| Winnebago Co. #3 | 1946 | — | 653 | 50 | 13.06 | — | — | — | — | — |
| Winnebago Co. #3 | 1947 | 281 | 281 | 50 | 5.62 | 411 | 9.42 | 129 | 119 | 121 |
| Winnebago Co. #3 | 1948 | 112 | 112 | 50 | 2.24 | 559 | 15.83 | 183 | 126 | 133 |
| Winnebago Co. #4 | 1947 | 60 | ±300 | 30 | 10.00 | 253 | 5.37 | 112 | 79 | 88 |
| Winnebago Co. #4 | 1948 | 67 | 67 | 30 | 2.23 | 191 | 3.67 | 92 | 109 | 103 |
| Winnebago Co. #5 | 1947 | 113 | ±1,000 | 160 | 6.25 | 250 | 5.62 | 125 | 181 | 162 |
| Winnebago Co. #5 | 1948 | 255 | 255 | 160 | 1.59 | 673 | 13.06 | 94 | 144 | 136 |
| Winnebago Co. #6 | 1947 | 845 | 845 | — | — | 565 | 13.10 | 131 | 259 | 231 |
| Winnebago Co. #7 | 1946 | — | 690 | 700 | 0.98 | — | — | — | — | — |
| Winnebago Co. #7 | 1947 | 383 | 383 | 700 | 0.55 | 261 | 5.43 | 108 | 172 | 150 |
| Winnebago Co. #8 | 1947 | 260 | — | 210 | — | 373 | 8.54 | 129 | 181 | 168 |
| Dodge Co. #1 | 1947 | 110 | 110 | 25 | 4.40 | 424 | 8.90 | 110 | 102 | 104 |
| Dodge Co. #2 | 1947 | 176 | — | — | — | 468 | 9.66 | 107 | 130 | 126 |
| Dodge Co. #3 | 1947 | 45 | — | — | — | 462 | 9.25 | 100 | 105 | 104 |
| Dodge Co. #4 | 1947 | 63 | — | — | — | 425 | 8.50 | 100 | 200 | 173 |
| Columbia Co. #1 | 1945 | — | 0 | — | 0 | — | — | — | — | — |
| Columbia Co. #1 | 1946 | 203 | — | — | — | 361 | 8.37 | 131 | 124 | 126 |
| Calumet Co. #1 | 1946 | — | 576 | 96 | 6.00 | — | — | — | — | — |
| Calumet Co. #1 | 1947 | 62 | — | 96 | — | 343 | 6.86 | 100 | 200 | 169 |
| Dane Co. #1 | 1945 | — | 0 | — | 0 | — | — | — | — | — |
| Dane Co. #1 | 1946 | 125 | — | — | — | 635 | 21.60 | 240 | 80 | 92 |
| | | 24,082 | | | | 362 | 7.23 | 99.8 | 134 | 125 |

The Horicon Marsh Wildlife Area, for the purpose of management is divided into a number of permanent trapping areas which range in size from 50 to 125 acres. Trapping data from those areas which had adequate water through the year so that environmental conditions were relatively uniform from

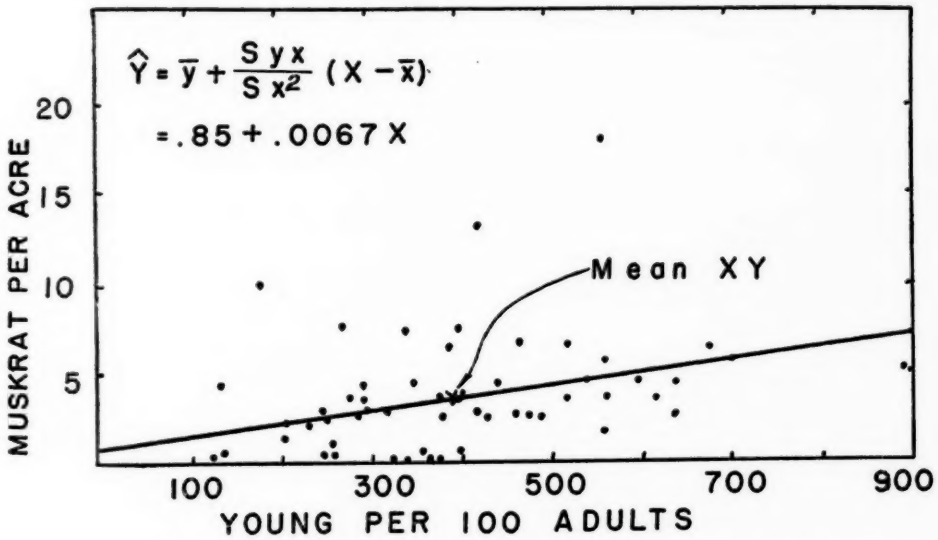


FIG. 1. Regression of muskrats per acre taken the previous year on young per 100 adults from management areas on Horicon Marsh Wildlife area. The date is from 1946, 1947, and 1948.

year to year and from area to area were used to calculate the regression line of muskrats taken per acre the previous year on the number of young per hundred adults (see Fig. 1). These data show that the number of young per adult available to the fall trapping season is inversely related to the density of the breeding stock. When this regression was tested by Fisher's "t" test a value of 2.56 was obtained, which is significant at the 0.05 level.

In examining the data in Table 4, it is seen that there is a trend toward a higher proportion of males in the adult population with the higher ratios of young to adults, though from a statistical standpoint these groups might have been drawn from a single intermediate population. With more data this trend will probably be found to be valid since the data from live trapping and tagging indicate that the adult males fight among themselves more than do the adult females. This suggests that the greater the breeding density the higher the mortality on the adult males which would tend to bring the adult sex ratio to even or favoring the females.

In grouping the sex ratios of the immature animals for the three age-ratio groups given in Table 5 it was found that the first two groups had identical sex ratios, 128 males per 100 females (56.0% males), but the third group had a ratio of 156 males per 100 females

(60.9% males). This is significantly different from the other two samples at the 0.01 level. This indicates that in a low density population there is probably some factor that works relatively against the immature females.

These data indicate that it is possible to determine the condition of a muskrat population from the sex and age ratios.

Table 4.—Adult Sex Ratio in Relation to Young per 100 Adults[1]

| Yg. per 100 ad. | ♂♂ | ♀♀ | Ratio of ♂♂ per 100 ♀♀ | Per Cent ♂♂ | Sampling[2] Limits of Per Cent |
|---|---|---|---|---|---|
| 100–300 | 977 | 1,038 | 94.1 | 48.5 | ±1.8 |
| 301–500 | 1,708 | 1,657 | 103 | 50.7 | ±1.5 |
| 501–700 | 411 | 353 | 116 | 53.7 | ±3.1 |

[1] This table includes data from Errington (1943) and Baumgartner and Bellrose (1943) as well as data from Table 4.
[2] Sampling limits at the 0.05 probability level.

Table 5.—Immature Sex Ratio in Relation to Young per 100 Adults

| Yg. per 100 ad. | ♂♂ | ♀♀ | Ratio of ♂♂ per 100 ♀♀ | Per Cent ♂♂ | Sampling* Limits of Per Cent |
|---|---|---|---|---|---|
| 100–300 | 2,779 | 2,167 | 128 | 56.1 | ±1.6 |
| 301–500 | 7,236 | 5,654 | 128 | 56.1 | ±1.0 |
| 501–700 | 2,709 | 1,740 | 156 | 60.9 | ±2.3 |

* Sampling limits at the 0.01 probability level.

The indicators of over-population are low immature to adult age ratio and an adult sex ratio which is even or in favor of the females while indicators of low density populations are high immature to adult age ratio, the adult sex ratio definitely favoring the adult males and the immature sex ratio favoring the males.

With the data that are on hand it is difficult to determine from a statistical standpoint what constitutes over, under or optimum trapping pressure, but we feel that an age ratio of 400 to 500 young per 100 adults is fairly near to being optimum for Wisconsin areas.

## Summary

The sex ratio of the muskrat is fairly close to being even at birth but by the time the young are about three weeks old the ratio has shifted to about 140 males per 100 females. There is then little or no shift in sex ratio until the following breeding season when the ratio becomes about even.

The average number of young produced per adult female is 15.5 per season as determined by placental scar counts. About 3 per cent of the adult females had not born young.

The age ratios in 24,082 fall-caught muskrats was 359 young per 100 adults. The per cent of young was inversely related to the density of the breeding population.

For Wisconsin marsh habitat the best utilization was obtained when the popu-

lation has an age ratio of 400 to 500 young per 100 adults in the fall.

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# PRODUCTION OF MALLARDS ON IRRIGATED LAND IN THE SACRAMENTO VALLEY, CALIFORNIA

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The primary aim of the investigation here reported was to measure the production of mallards on the Conaway ranch, an area of irrigated farm land in the Sacramento Valley of California. Production was calculated from census figures of (1) the breeding population at the onset of nesting, and (2) the total mallard population (young and surviving adults) at the period in midsummer when the young were beginning to fly. A secondary objective was to study the ecology of nesting in order to understand the limitations in production. The various phases of the study are recorded in the chronological order in which they were completed, with discussion of total production deferred to the end, following the postbreeding census.

Acknowledgments are gratefully made to A. Starker Leopold, Museum of Vertebrate Zoology, University of California, and to John E. Chattin, California Division of Fish and Game, for suggestions and supervision of this investigation. Likewise I wish to express appreciation to Lee Baldock and other personnel of the Conaway ranch for their many courtesies. During the period of the field work (February 15, 1948 to February 1, 1949) the author was in the employ of the California Division of Fish and Game (Federal Aid in Wildlife Restoration Project 30-R).

## Description of Study Area

The Conaway ranch is situated five miles southeast of Woodland, Yolo County, California, in the center of the Sacramento Valley. The ranch consists of approximately 19,000 acres of irrigated land, typical of much of the surrounding valley. There are over 300 miles of irrigation ditch on the ranch, but due to the varied nature and needs of the crops, only 50 to 75 miles of ditch contained water at any one time during the period of the field study. Most of the ditches are bordered by roads, which facilitated observation of the ducks.

The bulk of the ranch is farmed in a three-year crop rotation of rice, fallow, and small grain. About nine per cent of the area is in permanent irrigated pasture. The acreage of pasture is being increased as rapidly as the ground can be leveled, a process which will lead to future reduction in the acreage of grain with a corresponding increase in livestock production.

The major cover types, being of varied importance to the resident mallard population, are discussed individually below. Acreages are summarized in Table 1.

(1) *Rice:* Rice in this area is normally planted in April. However, in 1948, due to late spring rains and cold weather, it was sowed in May. Actual planting is done by airplane, the seed being broadcast on the flooded fields. Since rice is flooded during the entire growing season, the only available area for nesting in the rice fields is on the check dams, which after May 15 have a cover composed mainly of watergrass (*Echino-*

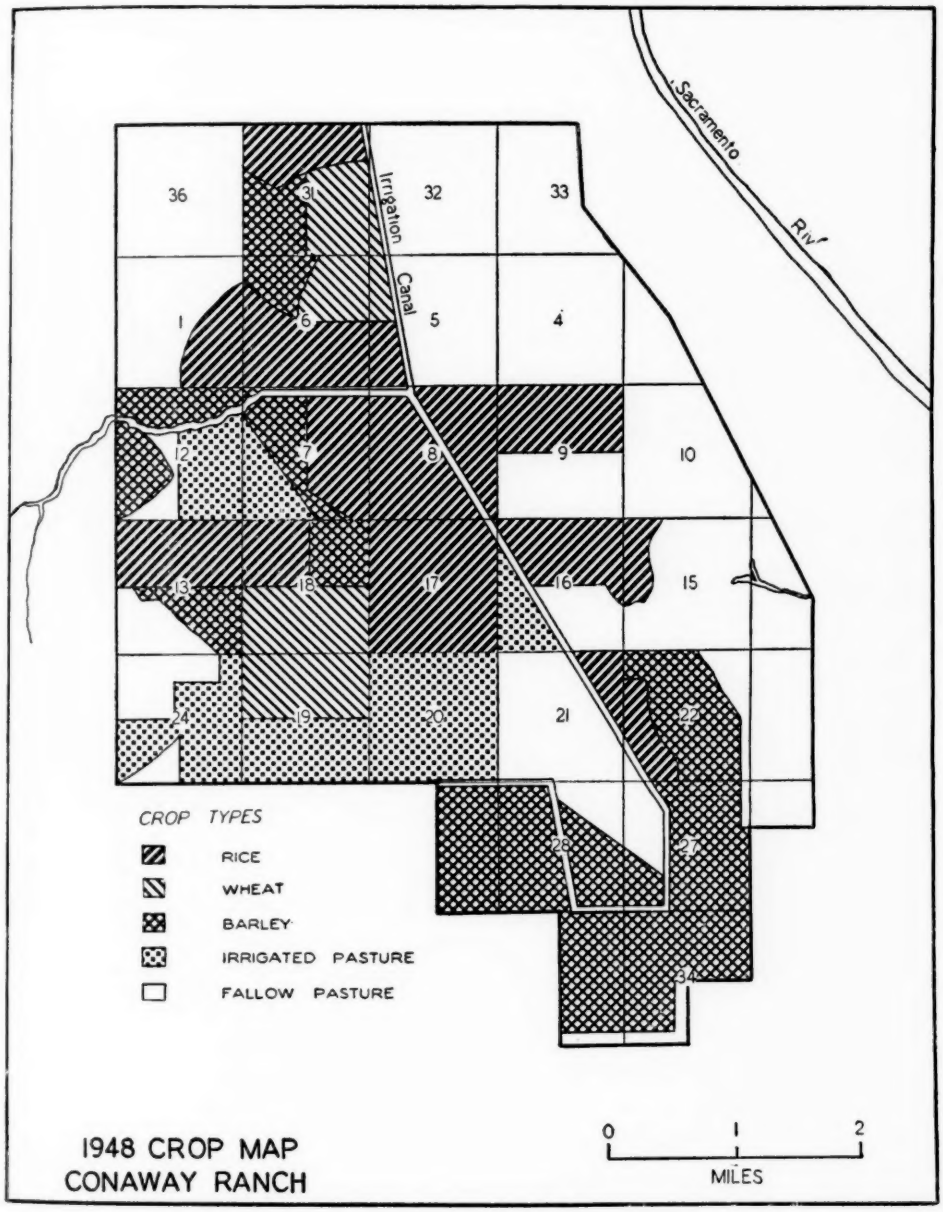


FIG. 1. Crop map of Conaway ranch in 1948.

*chloa crusgalli*), beardgrass (*Polypogon monspeliensis*), and mustard (*Brassica campestris*). During the early part of the nesting season the growth on the check dams was sparse, so they were only available for late nesting. In 1948

the rice fields were drained and the crop harvested in early November. Ordinarily the harvest is completed by mid-October.

The primary importance of the rice fields to the breeding ducks is as summer cover for broods. As soon as the rice is high enough to afford protection, the hens lead their broods to the flooded fields, where they remain until the ducklings are fledged. Later the rice serves as an important source of winter food for the entire population of mallards.

TABLE 1.—COVER-TYPE ACREAGES ON THE CONAWAY RANCH IN 1948

| Cover-type | Acres |
|---|---|
| Rice | 3,400 |
| Fallow pasture | 5,500 |
| Barley | 3,210 |
| Wheat | 1,100 |
| Irrigated pasture | 1,640 |
| Flooded land | 2,770 |
| Ditchbanks and roadsides | 1,130 |
| Tule swales | 55 |
| Total | 18,805 |

Those agricultural areas in the Sacramento Valley that are lacking in rice fields have few or no ducks during the spring and summer. Thus rice acreage is apparently the key to mallard production in this region.

(2) *Fallow pasture:* Fallow pasture, composed largely of the previous year's rice stubble, was little used by the nesting ducks. It is grazed by sheep through the winter and spring, leaving insufficient cover for nests. The only extensive use made of the fallow fields was on areas flooded by the heavy spring rains. These transient ponds were used early in the season (February and March) for loafing and feeding.

In the fall the ground is plowed in preparation for the planting of small grains.

(3) *Wheat:* Wheat is planted in late October and early November. It grows slowly until the arrival of warm spring weather and then shoots up rapidly, attaining a height of 18 to 30 inches by the start of the duck nesting season. The wheat fields proved to be the most important nesting cover for mallards in 1948. Wheat is harvested in June and July and the fields are plowed in the late fall preparatory to the planting of rice in the spring.

(4) *Barley:* Barley culture is similar to that of wheat, the crop being planted in the early winter months and harvested in June and July. The barley was used to a minor extent by the nesting mallards.

(5) *Irrigated pasture:* Irrigated pasture supports a lush growth of ladino clover mixed with various weeds, such as dock (*Rumex* spp.), bull thistle (*Circium lanceolatum*), star thistle (*Centaurea solstitialis*), and jointgrass (*Paspalum distichum*). The growth in 1948 ranged from six to twelve inches when nesting started. The pasture is irrigated approximately every twenty days, depending on rainfall. Water is held on the pasture by parallel checks thirty feet apart. Sheep are grazed on the irrigated pasture in fall, winter, and spring, and cattle in the summer. Ducks used the area for nesting despite hazards of flooding and grazing.

(6) *Flooded land:* Approximately half of the Conaway ranch lies in the Yolo bypass, a two mile wide channel serving as an overflow basin for the Sacramento River in flood years. During 1948, high water in the river caused the bypass to be flooded on April 19. Water completely covered the area for two weeks,

and gradually receded through late April and May. Most of the area flooded on the ranch was fallow pasture, which caused no agricultural loss. However, about 2,770 acres of land in the bypass had been prepared for rice. The checks were washed away and no crop was planted.

The flood, occurring as it did during April and May, forced the mallards to nest almost entirely on the unflooded part of the ranch, thus considerably reducing the area of potential nesting ground and possibly cutting down somewhat on total production.

(7) *Ditchbanks and roadsides:* Spoilbanks along roads and irrigation ditches generally are covered with a dense growth of weeds and grasses, of which the most important are: wild oats (*Avena fatua*), mustard (*Brassica campestris*), bull thistle (*Cirsium lanceolatum*), star thistle (*Centaurea solstitialis*), pigweed (*Amaranthus retroflexus*), and mallow (*Malva borealis*). The ditches themselves contain a growth of tules (*Scirpus* spp.) and cattails (*Typha latifolia*). Periodically this growth becomes so dense as to necessitate redredging. On the Conaway ranch, ditch cleaning is done every two or three years, where necessary.

Spoilbanks were used for nesting by the mallards. In addition, the water area of the ditches was used for territories, for loafing, and for brood cover during the early part of the hatching season before the rice had emerged.

(8) *Tule swales:* One small tract of about 55 acres is not farmed because of the alkaline character of the soil. The center of the area is flooded during the winter and spring and contains a dense growth of tules. The edges are grown over with various alkali-tolerant plants, such as salt grass (*Distichlis spicata*), beard grass (*Polypogon monspeliensis*), and alkali clover (*Cressa cretica*).

Some nesting took place on the edges of this area, but it was more important as a spring loafing site than as nesting ground.

### PRE-NESTING PERIOD

The breeding population of mallards was censused by counting territorial pairs along the ditches, where virtually all territories were established. When the investigation began in February, 75 per cent of the mallards on the ranch were paired, and by the end of March only five per cent remained unpaired. Early pairing in this species has been described by Phillips (1923:29), Girard (1941), and others. However, while pairing was almost complete in February, there was no evidence of territorial behavior at this time. Most of the mallards were found in large concentrations on temporary ponds of standing rain water in the fallow pastures. Occasional birds found on the irrigation ditches were in groups of four to ten.

First actual territorial behavior was seen on March 19, when a drake was observed driving an intruding pair away from a section of ditch. Following this, mallards were seen less and less frequently in groups and more often in pairs spaced at intervals along the ditches. The actual length of ditch defended appeared to depend upon the width of the ditch, wider ditches seemingly furnishing more territories per unit length. In a ditch about five feet wide, the average territory was 70 yards in length. This was determined by slowly driving drakes known to be on territories along the ditch until a point was reached beyond which they

would not go but rather turned back toward the observer or escaped by flying. Extremes were 48 and 95 yards.

Observed territorial behavior, following the pattern described by Hochbaum (1944), reached a peak in the period of April 5 to 9, and then dropped off rapidly. Males apparently abandoned their territories shortly after the females began to incubate. This is concluded from the fact that the peak of the hatch occurred during the week of May 16 to 22. Allowing 26 to 28 days for an average incubation period, we find that the date of the beginning of incubation falls approximately two weeks after the period of the peak of territorial behavior. Occasional indications of territorial behavior were seen until the end of April, presumably due to late nesting.

If water were the only consideration in the selection of a territory, the mallards did not utilize all the potential sites on the ranch. With an average territory length of 70 yards, or 210 feet, there were a minimum of 1,255 possible territories. Only about a third of these potential territories actually were occupied. Either there were not enough ducks to fill the available sites or parts of the ditches were lacking in some critical requirement, such as food, or loafing sites. It was noted that in ditches which recently had been dredged, and hence supported little or no emergent vegetation, mallards rarely were seen.

The average period of territorial occupancy for eight closely observed drakes was ten days. The extremes were eight and twelve days.

In counting the breeding population of the ranch care was taken to include only those drakes that actually seemed to be occupying territories. Ditches bordered by roads were censused every day, and ditches not bordered by roads were censused every three days throughout the entire territorial period. A weekly average was arrived at for each ditch. The total number of territorial drakes determined from these counts was 396; this was probably a conservative census. Since the sex ratio was nearly 50:50, each territorial drake was assumed to have a mate. The figure was rounded off to 400 pairs, and it is this number that is used in calculating production.

### NESTING PERIOD

In searching for mallard nests, various techniques were used. Females flying into or out of a given area were watched, and the points at which they landed were noted and searched for nests. The method was only moderately successful; a large amount of time was expended to find only a few nests.

A second method was walking back and forth through the area under search attempting to flush hens off the nests. Most of the nests were found in this way. Sometimes a long cane pole was carried to cover a wider strip.

The most successful method was the dragging of a hundred-foot rope stretched between two men, which allowed approximately a hundred-foot strip to be covered at one time. It was found that practically all hens would flush when the rope passed over head. However, this method was limited by the fact that two persons were necessary; therefore it was used only for about one week during the nesting period.

The earliest laying in nests under observation was April 13. However, hatch-

ing of clutches found later indicated that some hens started even earlier. For example, a clutch of eleven eggs hatched on May 9. Allowing a minimum of 35 days for laying and incubation, this clutch was started on approximately April 3. Another brood of newly hatched ducklings was observed on April 26; the clutch must have been initiated by the middle of March. I would class the latter case as exceptional, however. Most of the hens probably did not start laying before early April.

On the other hand, nests in which the clutches were not yet complete were found as late as the middle of June. These probably were second attempts, but there was no real evidence to prove this.

From the above observations it can be stated that the normal mallard nesting season in the Sacramento Valley, from the earliest laying to the latest hatching, extends from late March to the end of June.

## NEST COVER

Sixty nests were located during the 1948 season, distributed among the various cover types on the ranch, as shown in Table 2.

By mid-season, when these data were only half-compiled, the preference of the mallards for wheat as nesting cover became apparent. However, time spent and area covered in the different cover types was not equal, due to the varied accessibility of the types. Likewise the acreages of the various types were not equal. In order to test more equitably the distribution of nests in various cover types, a planned nest search was conducted with the aid of an assistant, W. V. Wiederhoeft, between the dates of June 7 and 11. Dragging a hundred-foot rope between us, Wiederhoeft and I devoted one day each to searching for nests in wheat, barley, ditchbanks and roadsides, irrigated pasture and fallow pasture. In each type we spent about five hours and covered roughly sixty acres of ground not previously visited. Tule swales, rice, and flooded land were not considered, the former because of its small acreage, and the latter two because of insufficient cover at the time. The results of this method of sampling also are shown in Table 2 under the column "planned search".

TABLE 2.—DISTRIBUTION OF NESTS BY COVER TYPE ON CONAWAY RANCH IN 1948

| Cover | Random Search | Planned Search* | Total Nests | Per Cent of Total Nests |
|---|---|---|---|---|
| Wheat | 18 | 8 | 26 | 43 |
| Ditchbanks and roadsides | 11 | 2 | 13 | 22 |
| Irrigated pasture | 6 | 1 | 7 | 12 |
| Fallow pasture | 5 | 0 | 5 | 8 |
| Rice | 4 | — | 4 | 7 |
| Tule swales | 3 | — | 3 | 5 |
| Barley | 0 | 2 | 2 | 3 |
| Flooded land | 0 | — | 0 | 0 |
| Total | 47 | 13 | 60 | 100 |

* Five hour search in each of five types by two men dragging a hundred-foot rope.

The fact that, in spending an almost equal amount of time in each major type, over 60 per cent of the nests found were in the wheat confirmed the pre-

vious conclusion that wheat was preferred nesting cover on this area in 1948. However, observations elsewhere in the Sacramento Valley, as for example on Grey Lodge Refuge in Butte County, showed that other cover types (tules, weed fields, etc.) were preferred locally. The predilection for wheat on the Conaway ranch may have been due to a shortage of adequate nesting cover most important source of loss, was chargeable mainly to mammalian predators. Only one case of a destroyed nest which could be attributed to crows was found and even this was doubtful. The principal nest predators were skunks, raccoons, and feral house cats. Insufficient evidence was obtained to determine which of these was the most important.

TABLE 3.—SUMMARIZED NEST RECORDS OF MALLARDS ON THE CONAWAY RANCH IN 1948

| Cover | Hatched: | Destroyed by: | | | | |
|---|---|---|---|---|---|---|
| | | Predation | Desertion | Livestock | Flooding | Totals |
| Wheat | 17 | 7 | 2 | — | — | 26 |
| Barley | — | — | 2 | — | — | 2 |
| Irrigated pasture | 1 | — | — | 5 | 1 | 7 |
| Fallow pasture | 4 | 1 | — | — | — | 5 |
| Rice | 3 | — | 1 | — | — | 4 |
| Tule swales | 2 | — | 1 | — | — | 3 |
| Ditchbanks and roadsides | 4 | 7 | 1 | — | 1 | 13 |
| Totals | 31 | 15 | 7 | 5 | 2 | 60 |
| Per cent | 52 | 25 | 12 | 8 | 3 | 100 |

in other fields during the early portion of the nesting season.

## NEST SUCCESS

It has been concluded by Kalmbach (1939) that the average degree of nesting success, based on twenty-two field studies of thirteen species of ducks, was 60 per cent. Mallard nesting success on the Conaway ranch in 1938 was only slightly over 50 per cent, falling below Kalmbach's figure.

In a discussion of nest fates, it should be understood that it is the termination of the clutches, either successfully or unsuccessfully, with which we are concerned. Fates of the broods after hatching are considered later.

The fates of the 60 nests found are shown in Table 3. Predation, being the

Some desertions probably were caused by too frequent interference on the part of the observer. Early in the nesting period, it was my practice to visit the nests every other day. The time between visits later was extended to a week.

Nest destruction by livestock was limited to the irrigated pasture where five nests were trampled by grazing sheep or cattle.

Two nests were flooded out—one by rising water in the ditch along which the next was built, the other during irrigation of permanent pasture.

Distribution of nest fates by cover types is also shown in Table 3. Over half the nests located along ditchbanks and roadsides were destroyed by predators. Ditches and roads are natural travel

lanes for predators and the cover strips are so narrow that presumably it would be easy for a skunk or raccoon to find a nest located there.

The only other large loss by predation was in the wheat. The writer is inclined to believe that this was due in part to trails made by himself in the process of visiting the nests. It was almost impossible to avoid leaving these trails even after a single visit. The wheat fields were crossed at regular intervals by small drainage ditches about three feet wide. The trail left by the observer invariably started at some point along one of these drainage ditches and led to the nest. It is difficult to believe that predators, starting at random at the edge of a large wheat field, could account for almost a third of the nests without some such advantage.

It is apparent from examination of Table 3 that those birds nesting in the irrigated pasture had the least chance of success due to the grazing of stock during the nesting season.

The previous discussion has been concerned with the termination of the clutch as a whole and not with the fate of the individual eggs. The eggs fate are summarized in Table 4.

The category "Left in hatched nests" includes 6 eggs found to be infertile, 5 eggs with embryos that died early in incubation, and 20 eggs with well developed embryos that apparently were abandoned by the hens after the hatching of part of the ducklings.

TABLE 4.—SUMMARIZED RECORDS OF MALLARD EGGS FOUND IN 60 NESTS, CONAWAY RANCH, 1948

| | Number of Eggs | Per Cent of Total |
|---|---|---|
| Hatched | 206 | 49.4 |
| Left in hatched nests | 31 | 7.4 |
| Predation | 104 | 24.9 |
| Desertion | 41 | 9.9 |
| Livestock | 23 | 5.5 |
| Flood | 12 | 2.9 |
| Total | 417 | 100.0 |

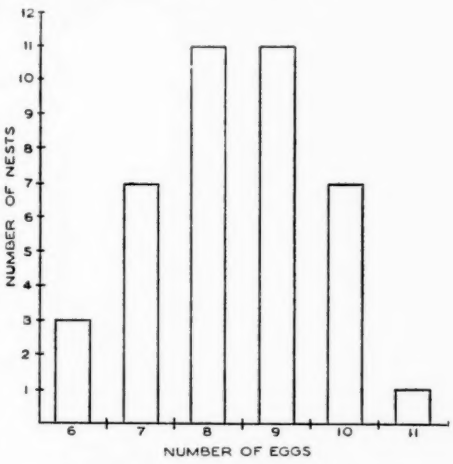


FIG. 2. Size of completed mallard clutches, based on 40 nests. The average clutch was 8.4 eggs

Of the 60 nests found, the clutches of 40 were believed to have been completed. The size distribution of the completed clutches is shown in Figure 2. The majority of the clutches had between 7 and 10 eggs; the average was 8.4.

The number of eggs in 30 of the 31 successful nests was known definitely. The average number of eggs per successful nest was 7.9. The average hatch was 6.9.

With the completion of the nesting season, it was possible to compute the period during which the peak of the hatch occurred. Known hatching dates of observed nests and estimated hatching dates of broods were combined, as shown in Figure 3. The peak of the hatch took place during the period May 16 to May 29.

A total of 106 broods were counted between June 15 and August 20. Estimated age in weeks (to the sixth week) and number of young were recorded for each brood; an average brood size was

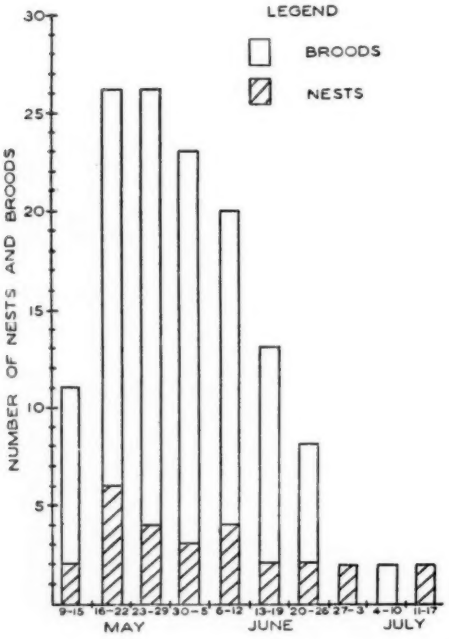


FIG. 3. Numbers of mallard clutches hatched, by weekly periods from May 9 to July 17, 1948, based both on nests studied and broods observed.

derived for each of the six age classes, as plotted in Figure 4. Whereas 6.9 young were hatched from the average successful nest, only 4.9 ducklings survived in broods up to a week of age. Thereafter mortality was progressively less and 3.6 young constituted the average brood at six weeks. It proved impossible to recognize individual broods beyond that age.

Girard (1941) found a production of approximately 4 young per hen mallard at the flapper stage. In a compilation of waterfowl populations and breeding conditions by Williams *et al.* (1948), average brood size of fledgling mallards ranged between 4 and 7.5 in 1948. My figures obtained on the Conaway ranch indicate a somewhat lower rate of productivity, the average fledged brood being perhaps a little over 3 young.

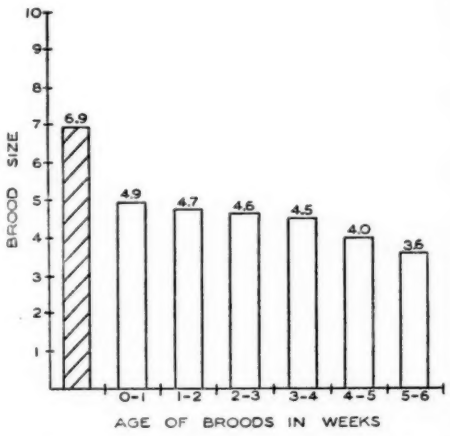


FIG. 4. Average size of mallard broods by age groups, showing gradual decrease in brood size up to the sixth week.

## POST-BREEDING CENSUSES

Ground censuses were taken during the months of July and August. Two sample areas, each consisting of 160 acres of rice, were censused. These areas were the northwest quarters of Sections 9 and 17, respectively. Since virtually all the mallards on the ranch had moved to the rice fields by this time, it was felt that a census in the rice would give an approximate count for the whole ranch. The drakes were assumed to be in the rice fields undergoing the eclipse molt. It is well known that male ducks frequently leave the breeding grounds at this time and concentrate elsewhere during the flightless period. However, I had no evidence of any such movement and since some

drakes were observed I have postulated that all the breeding males still were present.

The census method involved walking the check dams in each plot, counting all mallards seen. The ducks tended to congregate on the checks and to swim back to the same check after being disturbed, thus causing little or no duplication in the count. The censuses were made on July 27, August 3, and August 10. The; figures were then added, averaged, and the number of ducks per acre derived, as shown in Table 5.

The acreage of rice in 1948 was 3,400. Applying the average figure of .72 ducks per acre to this, we derive a total of 2,448 ducks on the ranch.

TABLE 5.—GROUND CENSUS OF DUCKS PER ACRE IN RICE FIELDS DURING JULY AND AUGUST, 1948

| | July 27 | August 3 | August 10 | Average |
|---|---|---|---|---|
| Total Ducks counted on 300 acres | 253 | 225 | 212 | 230 |
| Average ducks per acre | .79 | .70 | .66 | .72 |

An aerial census was taken on August 12. All of the rice fields on the ranch were censused. The method employed was to divide the fields into strips of approximately one-eighth of a mile and fly along the edge of each strip at an elevation of 100 feet, counting the ducks on one strip at a time. The rice was only six to eight inches high at the time and it was found that the ducks were easily counted from this elevation. The total count obtained by this method was 2,055 ducks. It is felt that this is a more accurate figure than that obtained from the ground census, as the latter was a sample count subject to the usual errors of sampling. Also the ground counts were taken over a longer period during which there may have been local shifts in the population, as well as some mortality among the ducklings, which could account for the variable results shown in Table 5.

## CONCLUSIONS REGARDING TOTAL PRODUCTION

Accepting as accurate the pre-breeding census of 400 pairs (or 800 breeders), we can calculate the production in three ways, as shown in Table 6.

On the basis of the ground census which indicated a post-breeding population of 2,448 birds, the 400 pairs would have produced an average of 4.1 young. The somewhat more conservative total count of 2,055 birds made from the air would indicate an average production of 3.1 young per pair. Both of these figures assume no mortality among the breeding adults. Since some mortality does occur, the average number of young is in each case conservative since the totals would thereby consist of less than 800 adults and correspondingly more young.

Actual brood counts, summarized in fig. 4, showed an average brood of 3.6 young at the age of six weeks. Since all pairs certainly did not produce broods, the calculated total population of 2,240, obtained by multiplying 400 pairs by 3.6, would be high. This tends to strengthen the supposition that the aerial count is more nearly accurate than the sample ground count.

On the basis of these data, it would seem that an approximate feeding population of 800 mallards increased to a population of about 2,000 birds in late summer. On the 19,000 acre Conaway ranch this would mean that one

young duck was produced per 15 acres. Applying the same data to the 3,400 acres of rice on the ranch indicates production of one duckling per 2.8 acres of rice.

In 1948 the Sacramento Valley had approximately 185,000 acres of growing rice. Since rice acreage is presumably the key to mallard production in this area, the above figures when applied to the entire valley would give an approximate total production of 65,000 young mallards raised by a calculated breeding population of 44,000.

6.9 ducklings. Over half of the failures were due to predation.

Counts obtained on 106 broods indicated an average brood of 4.9 ducklings during the first week after hatching. Brood size gradually decreased until in the sixth week, when counting ceased. They averaged 3.6 young.

Post-breeding censuses indicated an approximate population of 2,000 young and adults. Each of the original pairs therefore produced about three young ducks, for a gross production on the ranch of one bird per 2.8 acres of rice.

TABLE 6.—SUMMARIZED DATA BEARING ON TOTAL PRODUCTION OF MALLARDS ON THE CONAWAY RANCH IN 1948. CALCULATED OR DERIVED FIGURES ARE ENCLOSED IN PARENTHESES.

| Based on: | Breeding Population | Production per Pair | Total Young | Total Post-Breeding Population |
|---|---|---|---|---|
| Ground census | 800 | (4.1) | (1,648) | 2,448 |
| Aerial census | 800 | (3.1 | (1,255) | 2,055 |
| Brood counts | 800 | 3.6 | (under 1,440) | (under 2,240) |

## SUMMARY

The mallard nesting season on the Conaway ranch was found to extend from the first of April through the middle of July. Breeding territories were located along irrigation ditches, an average territory comprising about 70 yards of ditch. The average period of occupancy of a territory was ten days. Peak of territorial behavior occurred during the period April 5 to 9. The breeding population was determined to be about 400 pairs by counting territorial males along the ditches.

Sixty nests were found, approximately half of them in wheat. Fifty-two per cent of the observed nests hatched successfully, the average hatch being

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PHILLIPS, JOHN C. 1923. A natural history of the ducks. Vol. 2. Houghton Mifflin Co., New York, N. Y., 409 pp.

WILLIAMS, C. S. *et al.* 1948. Waterfowl populations and breeding conditions. U. S. Fish and Wl. Serv. and Dom. Canad. Wl. Serv., Spec. Sci. Rep. 60, 186 pp.

Accepted for Publication November 8, 1949.

# THE WILDLIFE SOCIETY

## Report of the Secretary—1949

Even though the incumbent Secretary took over his new duties on May 1, 1949, this report will cover the period from January 1, 1949 to December 31, 1949. This is being done in order to have this report consistent with other records of the Society. By-law 15 of the Constitution of the Wildlife Society states that the fiscal year of the Society shall end December 31. The Treasurer's-report of finances is for that period and annual dues, subscriptions and volumes of the Journal all adhere to that time period.

Because of this reporting change there will be a slight over-lapping of information covered by the previous Secretary, Dr. George Petrides. This new system will also permit more time for the Secretary to prepare the annual report before the annual business meeting.

The Society has shown a steady growth during the year with the addition of 226 new associate members and 66 new active members—quite a high percentage of the new actives were new members of the Society.

As of December 31, 1949, there were 643 active and 965 associate members and 245 subscribers. These subscriptions are going to 46 states, District of Columbia, Alaska, Hawaii, Canada, and 14 foreign countries.

The table below shows the membership classification by regions as of December 31, 1949.

| Regions | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Foreign |
|---|---|---|---|---|---|---|---|---|
| Active | 163 | 78 | 157 | 79 | 47 | 92 | 26 | 1 |
| Associate | 208 | 104 | 252 | 104 | 59 | 187 | 45 | 6 |
| Totals | 371 | 182 | 409 | 183 | 106 | 279 | 71 | 7 |
| Per cent actives | 44 | 43 | 38 | 43 | 44 | 33 | 37 | |

For the total membership, only 40 per cent are in active status and 60 per cent associates. In looking over the membership list, it is apparent that at least 80 per cent are eligible for active status under present standards. This means that if we intend to maintain the dual membership the regional representatives and membership committee have a big job ahead in trying to increase the number of active members in the Society.

There are still 74 individuals who were members in 1948 that have permitted themselves to be dropped from the Society membership. All delinquents were so notified in July 1949 and about half of those then in arrears responded to the notice.

It is the opinion of the Secretary that a high percentage of those still delinquent will eventually come through with their renewal of membership.

Resignations were received from seven members at the close of the calendar year.

It is with regret that it is necessary

to report the death of six members during the year. These were: Harry F. Harper, Henry E. Predmore, Jr., John Pearce, Frank Thone, Charles T. Vorhies, and Frederick C. Walcott.

During the eight months the Secretary has been in office, approximately 1,800 pieces of correspondence have been sent out. This represents a lot of work, especially on the part of his secretary, Mrs. Ewing. Thanks is hereby extended to her for the splendid assistance she has contributed.

Assistance was given the American Society of Ichthyologists and Herpetologists and the Entomological Society in drawing up incorporation papers and papers for exempting them from taxation.

The Finance Committee and Council unanimously passed a recommendation to reinvest certain securities of the Society that are at present in speculative stocks to more stable investments such as government bonds. It was generally felt that the Society, with its small financial reserve, could ill afford to take a chance with speculative investments.

The Council approved and the Treasurer contributed $50 to the Technical Conference on the Protection of Nature.

W. L. McAtee who has been the single member of the Memorials Committee since the war asked to be relieved of this duty last October. It is with regret that we lose him in this capacity, but wish to thank him for the excellent job he did in preparing obituaries for our deceased members.

Dr. Lee Yeager accepted the appointment to take over the obituary work vacated by Mr. McAtee. He has already written two obituaries and from them we are convinced the job is in capable hands.

A listing of members was prepared and published in the October issue of the Journal. The constitution and by-laws were not reprinted as there were no changes from the 1948 printing.

The Secretary wishes to extend his thanks to the other Council members, Committees, and Editor for their fine cooperation in handling the Society business.

Respectfully submitted
March 5, 1950
SHALER E. ALDOUS, *Secretary*

## TREASURER'S STATEMENT OF RECEIPTS AND DISBURSEMENTS
## For the Year Ending December 31, 1949

| | | |
|---|---|---|
| *Balance* January 1, 1949 | | $ 7,821.19 |
| *Receipts* | | |
| Associates | $ 4,087.20 | |
| Actives | 3,086.65 | |
| Subscriptions | 1,502.96 | |
| Back issues | 1,582.95 | |
| Dividends, Interest, and miscellaneous | 240.61 | |
| Payment overruns | 465.67 | 10,966.04 |
| | | $18,787.23 |

| | | |
|---|---|---|
| *Disbursements* | | |
| Printing of publications | $ 6,151.96 | |
| Printing, other than publications | 953.08 | |
| Office and administrative expenses and supplies | 236.58 | |
| Freight, express, and postage | 227.81 | |
| Miscellaneous | 59.00 | |
| Conference and editor's expense | 41.63 | |
| Wages and professional services | 225.56 | |
| Contributions | 105.00 | |
| Awards and refunds | 217.70 | $ 8,218.32 |
| *Balance*, December 31, 1949 | | $10,568.91 |
| *Accountable* as follows | | |
| Balance in bank | $ 9,916.31 | |
| Cash on hand deposited January 3, 1950 | 652.60 | $10,568.91 |

(Examined and found correct by Homer J. Henning & Company, certified public accountants, Lawrence, Kansas, February 28, 1950.)

## REPORT OF THE BUSINESS MEETING OF THE COUNCIL

The Council convened at 7:30 P.M. on March 5 in the Fairmont Hotel, San Francisco, Calif. Council members, Clarence Cottam, Edward Kalmbach, Shaler Aldous, Starker Leopold, Wm. B. Davis and C. H. D. Clark were present. Region 3 was represented by Earl C. O'Roke, and Region 1 by P. F. English. George Petrides, Lee Yeager, Tracy Storer and Gustav Swanson were present in an advisory capacity due to their past experience in Society matters.

Numerous items of business were discussed and are here reported in brief. It was the unanimous opinion of the Council that Life Membership was not transferable or redeemable where individuals choose to leave the wildlife field and no longer desire the professional association.

The present stock of back issues of the Journal of Wildlife Management is still ample for a short time but it was not felt that a reprinting of those low in supply was at present needed. Whether or not future printing should be made will be left to the next Council. This Council unanimously passed a resolution to raise the price of the first 8 volumes (through 1944) to $8.00 per volume. This new price will go into effect on July 1, 1950. Notices of this change will be posted in the next issues of the Journal and Newsletter so that every member so desiring can complete his set at the current $6.00 rate.

The Council unanimously recommended the reappointment of Herford N. Elliott to the trusteeship of the Society.

The question of reinstating active members after being delinquent for several years was discussed. It was agreed that if an individual left the Society in good standing we should reinstate him upon payment of current dues. If back numbers of the Journal are desired by such individuals they

must pay current prices (veterans excepted until December 31, 1950). It was also agreed that the Secretary be authorized to destroy miscellaneous papers on members in delinquent status over two years. The Society files are being filled with a lot of useless material which must be reduced in order to permit the Secretary to operate efficiently.

The Secretary is constantly being asked to place big libraries and international libraries on the free mailing list. The Council agreed that this is impossible in view of the Society's small budget. However, they unanimously agreed that the Library of Congress should be placed on the free list to receive all back issues and current ones as they appear. It was their concerted opinion that the Society has more to gain than lose in this matter.

The question repeatedly arises as to whether the Journal should publish manuscripts of non-members. The Council agreed that decisions in this matter should be left to the discretion of the Editorial Committee and the President. It was felt that at times articles by non-members would be of great value to the membership. Those individuals however should be invited to join the Society.

Numerous subscribers have requested the Newsletter, which at present goes only to members. The Council agreed to send the Newsletter to all subscribers inasmuch as the additional cost would be very little. As a means of reducing costs the Secretary was directed to investigate the savings to be made by mailing the Newsletter and Journal in the same wrapper.

The cost of the Newsletter has been going up constantly and in order to properly budget our funds it was agreed that the Newsletter would have to keep within the budget allowed even if reduction in size is necessary.

In the past, reprints of obituaries have been paid for personally by members or officers. The Council feels that this is an unjust burden and authorized the editor to order the minimum number possible and charge them to the Society. The Secretary was directed to negotiate with the publishers in obtaining a minimum cost on these reprints.

The Council unanimously passed a resolution to have the President write a letter on behalf of the Society to the widow of the late Doctor Rudolf Bennitt who died last month. Doctor Bennitt was one of our most active members and the first President of the Society.

In the past the list of members has been published in each October issue of the Journal. While this is desirable the Council agreed that it would be economically wise to restrict this listing to every two years. The 37 pages devoted to the membership list will permit the publication of at least two additional manuscripts or reduce the printing costs proportionally.

An editorial budget for putting out the Journal of Wildlife Management was set at $6,000.00 for the present (1950) year.

Doctor Gustav Swanson was retained as Editor by a unanimous vote of the Council. Two new members of the Membership Committee were approved by the Council. They were Doctor Walter P. Taylor and Doctor George Petrides. Doctor Taylor was

named as Chairman of this Committee. Doctors Needham, Dalke and Mr. Goodrum continue their places on this Committee. The Council expressed gratitude to Doctors Richer and Kutz for their excellent work on this Committee during the past year. The special study Committee for Organizational Review recommended that the Program Policy and the Advisory Committees be abolished as their functions were not clearly defined and therefore performed no useful service. The Council unanimously approved this action.

The Memorials Committee reported that they felt no publication in 1949 merited the Society award and that no award be given until next year. Publications of 1949 are to be judged in the awards for next year. The Council agreed to this action.

The Secretary's report of last year made the following statement: "By mail ballot, changes in the Constitution were proposed which provided (1) that Honorary Members might vote and hold office, (2) that Life Members might be elected by the Council, and (3) that the rule permitting ex-servicemen to purchase war-time issues at a reduced rate expired December 31, 1950. These proposals were overwhelmingly acceptable to the members who voted but they failed of passage because of the failure of two-thirds of the active members to return marked ballots." This matter was taken up with a Legal Authority and he ruled that the wording of the Constitution was such that these amendments should have been considered as passed because the voting results should be based on the number of votes actually cast and not on the total membership. The Council agreed that these changes should be incorporated in the next printing of the Constitution. The Committee on Constitutional Revision proposed three changes in the Constitution and the Council approved. In essence, they were:

1. To have only one class of membership which would be open to anyone interested in the field of Wildlife Management. The dues to all members would be $5.00. Life Members and Honorary Members would remain the same as would subscribers.

2. That the newly elected officers take office at the end of the annual meeting instead of May 1. This would be of great value to the new officers.

3. That the outgoing President automatically be made a Council member the year after his term as President.

These amendments will necessitate numerous changes in the wording of the Constitution which it is impossible to relate here. These will be written up in the Journal and pros and cons can be sent to the Newsletter so that all members can expound their different viewpoints on these changes.

## MINUTES OF THE ANNUAL MEETING OF THE WILDLIFE SOCIETY

The fourteenth annual business meeting of the Wildlife Society was called to order following the Society banquet, by President Clarence Cottam on March 6, 1950, in the Fairmount Hotel, San Francisco, California. The banquet was attended by approximately 80 members and the business meeting by 150.

The reading of the 1949 minutes of the Council and business meeting were

dispensed with because these were both printed in the July 1949 issue of the Journal and both sets of minutes were approved as printed.

Dr. Cottam made a few remarks, as President, giving thanks to the excellent assistance of the Council members during the year, to the good work of Dr. Swanson, Editor, and to Dr. Leedy and Mr. Gutermuth for their work in making arrangements for the business meeting.

A standing tribute to the late Dr. Rudolf Bennitt was expressed by the group. Dr. Bennitt, the first President of the Wildlife Society, passed away in February 1950. The list of past presidents of the Society was read as it was felt very few members were acquainted with that information. The list is as follows: Rudolf Bennitt 1937, Arthur A. Allen 1938, Aldo Leopold 1939, Victor H. Cahalane 1940, Richard Gerstell 1941, Paul R. Needham 1942, Walter P. Taylor 1943, Olaus J. Murie 1944, Lee E. Yeager 1945, P. F. English 1946, Logan J. Bennett 1947, Tracy I. Storer 1948, Clarence Cottam 1949.

The reports of the Secretary and Treasurer and the minutes of the Council meeting held in San Francisco were read and approved.

Regional reports were read or reported upon. The following is a condensation of their contents.

For Region 1—Representative Durward Allen reported: The Northeast Section of the Wildlife Society held its 1950 meeting at Syracuse, New York, on February 2, 3, and 4. The meeting was sponsored by the New York State College of Forestry and the New York State Conservation Department.

The Program Committee under Ralph T. King conducted by far the best meeting of its kind that has ever been held in the Northeast. Attendance was approximately 400, of which only a few were students of the University. Sessions were held under the following subject headings:

The Man with the Land
Habitat Improvement on Privately Owned Lands
Game Management and Research
Fish Management and Research
Game and Fish Administration

On Friday evening, February 3, a series of special meetings were held for groups with particular interests.

There is no doubt that this meeting sets a new standard for conferences of its kind in the Northeast. All State Departments, but one, in the region were represented and some appeared to have practically 100 per cent of their technical and administrative personnel present.

This section of the Society has been collecting $1.00 a year dues which have been used to meet secretarial and similar expenses. The Northeastern Section is a live and growing organization which is rapidly finding ways to be of increasing service to the people and agencies concerned with wildlife problems in the region.

For Region 2—Representative Clarence Watson reported in absentia: Our major accomplishment has been the setting up of a regional Section of the Society. A meeting of this group was held at Nags Head and witnessed the election of the present officers. Leonard Foote was elected President of the Southeastern Section.

The worthwhile news from Region 2

would be the setting up of the Section and the responsibility of the Section in organizing the annual technical sessions of the Southeastern Association of Fish and Game Commissioners. The By-Laws of the Southeastern Section are as follows:

I. The name of the Section shall be: Southeastern Wildlife Section.

II. Objectives of the Southeastern Wildlife Section shall be: (1) to sponsor consideration of technical game and fish management in Region II of the Wildlife Society, (2) to arrange for annual meetings at which appropriate discussions may be held, published and distributed, thus advancing the science and practice of wildlife management, and (3) to serve professional members of the Wildlife Society in the Southeastern Region in whatever manner may seem appropriate.

III. Membership: (1) Any active, associate, life, or honorary member of the Wildlife Society who lives in the Southeastern Region may become a member on payment of annual dues; and may be elected to any office and serve on committees in the Southeastern Wildlife Section. (2) Nonmembers of the Society and members who live outside of the Southeastern Region may participate actively in affairs of the Southeastern Wildlife Section; but they cannot hold elective offices in the Section.

IV. Officers of the Southeastern Section shall be a President, a Vice-President and a Secretary-Treasurer. They shall be elected at the first meeting of the Section each calendar year and shall hold office until the following election. The president shall appoint committees as he needs them. A vacancy in either of the elected offices will be filled by election at the next meeting of the Section.

V. Dues may be determined by majority action of those present at any authorized meeting (the organizational meeting held in Hotel Statler, Washington, D. C., March 7, 1949 established dues of 50 cents per member for the calendar year 1949).

VI. Further by-laws may be adopted and all may be amended at any meeting by majority vote of the members present.

For Region 3—Representative Warren Chase. During the past year, there were no regional meetings as such of the Society. Representatives, however, always get together at the Annual Midwest Wildlife Conference. This year we met at Madison, Wisconsin, on December 15, 16, and 17. Plans were made for the next conference which will be held in Columbus, Ohio, in the fall of 1950. The meeting at Madison, Wisconsin, was one of the best we have had in the Region with over 400 people in attendance.

Progress in wildlife management has gone ahead rapidly during this past year. Conservation organizations are set on a more firm basis than ever before and the reorganization of one conservation department has been put into effect. Michigan has set up three regional offices and placed their organization on a functional basis. This is now being analyzed to see whether it is working satisfactorily. Some of the other states are considering this same trend and it is understood that Wisconsin is considering a similar movement. In the long run it is hoped that this will mean that technicians in the

field of wildlife management will have a better opportunity to do more important field work than they have been allowed to do in the past.

There has been a great expansion in the training of wildlife managers. Courses and curricula are being reorganized and in at least one case a fish and wildlife management program is in effect. There has been a continuing high increase in enrollment and it looks as though there may be an excess of men trained in wildlife management within the next year or so. At the present time there are many proposed changes in the position of technicians within the Region and it looks as if 1950 will see a tremendous turn-over and improvements for many employees as well as opportunities for new men. Conditions in this Region still look excellent as far as employment goes.

For Region 4—Representative J. W. Kimball, absent, no report.

For Region 5—W. B. Davis, Representative, no formal report.

For Region 6—A. Starker Leopold, Representative, no formal report.

For Region 7—C. H. D. Clarke, Representative, no formal report.

Report of Committe on Leopold Memorial by Durward Allen. At the last annual meeting this Society provided for the creation of a Leopold Memorial Medal to be given annually, when an appropriate candidate is available, in recognition of distinguished service to Wildlife Conservation. This Committee was authorized to spend approximately $1,000.00 for the composition and execution of a design and the making of dies from which each year's medal can be struck off in bronze.

Estimates were obtained from several sculptors and the prices quoted ranged up to $1,500. Finally, we obtained an agreement with Mr. Gifford MacG. Proctor of Wilton, Connecticut, to do this art work for $500. Mr. Proctor did the medal for the Boone and Crocket Club and is well known for outstanding work in this field. We placed the job in his hands. A payment of $200 was made and the work is still in the designing stage.

The plan is that this committee will review and pass upon the design of the medal, which will be submitted in the form of sketches. A further payment of $200 will then be made and the sculptor will go ahead with the clay models, which will be 10 inches in diameter. When these are approved by the committee, the last payment of $100 will be made and Mr. Proctor will send the models to the Medallic Arts Company of New York City. This company will reduce the design to $2\frac{3}{4}$ inches and make the dies. The first medal will be struck off, engraved with the name of the winner, and made available for presentation. Their fee will be around $250. We estimate that four or five months will be required for the remainder of the work.

An added responsibility of this Committee was the selection of the individual to be honored at the first recipient of the Aldo Leopold Memorial Medal. Our choice is an elder statesman of wildlife conservation and we believe it will be universally approved. The first medal goes to J. N. (Ding) Darling. The medal will be inscribed with his name plus the year of presentation—1950. We propose that the President of the Society send an appropriate telegram of congratulation to Mr. Darling.

Report of the Awards Committee, by Durwald Allen. This committee has studied publications of 1949 in wildlife ecology and management with reference to criteria which seem to have been used by former committees acting for the Society in this capacity.

The annual award has been given for scientific, documented papers or monographs covering, at least in part, personal research. Several excellent books and papers in the wildlife field have appeared in 1949, but we do not believe that any of them fulfills the requirements of this award as we interpret them. We therefore submit a negative report.

Publications appearing late in the year are difficult for all members to obtain in time to give them proper appraisal, and the committee needs more time to consider the merits of all papers. Therefore, we suggest that this award be made to cover two years rather than one. This would insure that worthy works will not be overlooked in the haste now necessary at the end of the year. It will also permit recognition of two superior papers that appear in the same year. There will be the added advantage that each publication will be considered by two successive committees and in some degree permit the "test of time" to aid in decisions.

Resolutions were presented and passed as follows:

1. A vote of thanks to the officers of the Society, Committee members, the Wildlife Management Institute, and the management of the Fairmont Hotel.

2. That the Wildlife Society encourage the Fish and Wildlife Service, the Extension Service and the proper congressional committees to appropriate money for extension wildlife specialists to head a national program.

3. That the Wildlife Society support the move to stabilize the Pittman-Robertson fund at the $10 million level by using the backlog of funds in the Pittman-Robertson accumulations.

4. That the Wildlife Society commend the U. S. Corps of Engineers for their recognition of inspirational values of unspoiled areas as was the case regarding the Current River in Missouri.

5. That the Wildlife Society express its complete agreement with the International Committee for the Protection of Nature on their stand regarding the preservation of 27 vanishing wildlife species.

6. That the Wildlife Society express its interest in including upland migratory game birds under the Duck Stamp Act and that the stamp name be changed to Migratory Bird Stamp.

7. That the Wildlife Society express interest to the proper congressional committee to enact suitable legislation to permit Bureau of Plant Industry to study the oak leaf fungus which is threatening many oak species.

8. That the Wildlife Society urge passage of the Dingell Bill which will benefit sport fisheries.

9. That the Wildlife Society strenuously opposes the construction of high dams that interfere with fish and fishing in the Rogue River and its tributaries.

10. That the Wildlife Society commend the California Fish and Game Commission on its sound action for future appraisal of bird damage to crops before damage control is permitted.

SHALER E. ALDOUS, *Secretary*

## REPORT OF BALLOT COMMITTEE

The Committee audited the nomination and election ballots for The Wildlife Society for 1950–51 and found the following:

1. *Nomination Ballots.* Nominated for *President:* Ian McT. Cowan and Dr. S. A. Graham; *Vice-President:* Dr. D. I. Rasmussen and A. Starker Leopold; *Treasurer:* Walter A. Gresh and Robert D. McDowell; and *Regional Representatives: Region 1:* Dr. Durward L. Allen and Allan T. Studholme; *Region 2:* Dr. Clarence W. Watson and Leonard E. Foote; *Region 3:* Thomas R. Evans and Dr. Donald W. Douglass; *Region 4:* Dr. Lee E. Yeager and J. W. Kimball; *Region 5:* W. C. Glazener, Dr. William B. Davis, and Lee W. Arnold; *Region 6:* Dr. Paul R. Needham, J. Burton Lauckhart, Dr. Paul D. Dalke, Irven O. Buss, and Arthur S. Einarsen; *Region 7:* William J. K. Harkness and C. David Fowle.

2. *Election Ballots.* Results: *President:* Ian McT. Cowan; *Vice-President:* Dr. D. I. Rasmussen; *Treasurer:* Walter A. Gresh; *Regional Representatives: Region 1:* Dr. Durward L. Allen; *Region 2:* Dr. Clarence W. Watson; *Region 3:* Thomas R. Evans; *Region 4:* Dr. Lee E. Yeager; *Region 5:* W. C. Glazener; *Region 6:* Dr. Paul R. Needham; *Region 7:* William J. K. Harkness.

We find the above correct and final as of May 8, 1950.

WALTER P. SCHAEFER
C. EDWARD CARLSON, *Chairman*

## WILDLIFE SOCIETY PUBLICATION AWARDS

1940. Paul L. Errington, Frances Hamerstrom, Jr. The great horned owl and its prey in north-central United States. Iowa State College of Ag. and Mechanic Arts, Ag. Exp. Sta. Research Bull. 277: 759–850.

1941. Adolph Murie. Ecology of the coyote in the Yellowstone. Fauna of the Nat. Parks of the U. S., Bull. No. 4: xii +206 pp.

1942. No award.

1943. Henry S. Mosby and Charles O. Handley. The wild turkey in Virginia: its status, life history and management. Va. Comm. of Game and Inland Fisheries: xx+281 pp.

and Richard Gerstell. The place of winter feeding in practical wildlife management. Pa. Game Comm. Research Bull. No. 3: 121 pp.

1944. H. Albert Hochbaum. The canvasback on a prairie marsh. The American Wildlife Inst.: xii+201 pp.

and Durward L. Allen. Michigan fox squirrel management. Mich. Dept. of Conservation, Game Div. Publ. 100: 404 pp.

1945. W. L. McAtee (editor). The ring-necked pheasant and its management in North America. The American Wildlife Inst.: xii+320 pp.

1946. Paul L. Errington. Predation and vertebrate populations. Quart. Rev. of Biology, **21**(2): 144–177, and **21**(3): 221–245.

1947. Gardiner Bump, Robert W. Darrow, Frank C. Edminster, Walter F. Crissey. The ruffed grouse, life history, propagation, management. N. Y. State Cons. Dept.: xl+915 pp.

1948. Arthur S. Einarsen. The pronghorn antelope and its management. The Wildlife Management Inst.: xvi+238 pp.

1949. No award.

# OBITUARIES

## RUDOLF BENNITT

### 1898–1950

Rudolf Bennitt, Rucker Professor of Zoology, University of Missouri, died suddenly on February 2, 1950. Born at Springfield, Massachusetts, December 22, 1898, he received his professional training at Harvard University and graduated in 1923 with the Ph.D. in zoology. The same year he married Ruth Eunice Eynon, who, with two daughters, survives.

His background in general physiology was developed at Harvard under Dr. G. H. Parker. After serving an apprenticeship on the collecting staff, he instructed in invertebrate zoology, Marine Biological Laboratory, Woods Hole, Massachusetts. He taught at DePauw University in 1923 and then at Tufts College, 1924 to 1927. In 1927 he came to the University of Missouri where he was active until his death. The Missouri Cooperative Wildlife Research Unit was formed in 1937 with Rudolf Bennitt as chairman of the administrative committee. In 1944 he became the first appointee to the Rucker Professorship, a chair created as a memorial to the late William J. Rucker who donated $159,000 for wildlife conservation work at the University of Missouri.

His earliest intensive study in the field of wildlife conservation, "A Survey of the Resident Game and Furbearers of Missouri," published in 1937, was carried out in association with W. O. Nagel while on leave of absence from the University. This work had been preceded by a number of shorter publications, including "Check-list of the Birds of Missouri," 1932. His convictions relative to the training of men in the wildlife profession are expressed in his 1946 paper, "University Objectives in Professional Wildlife Training." His study of the Bobwhite quail covered an eleven-year period and, following several preliminary publications, culminated in a manuscript, "Some Aspects of Missouri Quail and Quail Hunting, 1938–1948." This will be published by the Missouri Conservation Commission.

Rudolf Bennitt was active in the organization of the Wildlife Society and became its first president. In Missouri he was widely known as a teacher and conservationist. He was a friend and close associate of the late E. Sydney Stephens, and with him contributed to the constitutional establishment of the Missouri Conservation Commission. A bronze plaque in the Wildlife Conservation Building, University of Missouri, reads:

> Rudolf Bennitt
> 1898–1950
>
> First chairman of the Missouri Wildlife Research Unit—1937–1950. Scholar, teacher and conservationist. His industry and unselfishness were largely responsible for the initial reputation of this unit.
>
> Erected by the Conservation Federation of Missouri in honor of his leadership and competence. April 22, 1950.

ROBERT S. CAMPBELL

### PUBLICATIONS, RUDOLF BENNITT


1922. Additions to the hydroid fauna of the Bermudas. Proc. Amer. Acad. Arts & Sci. 57, #10: 241–259.

1924. The migration of the retinal pigment in crustaceans. Jour. Exp. Zool., **40**: 381–435.

1932. Diurnal rhythm in the proximal pigment cells of the crayfish retina. Physiol. Zool., **5**(1): 65–69.

1932. Physiological inter-relationship in the eyes of decapod crustacea. Physiol. Zool., **5**(1): 49–64.

1932. Migration of the proximal retinal pigment in the crayfish in relation to oxygen deficiency. Biol. Bull., **62**(2): 168–177 (with A. D. Merrick).

1932. Note on the medusa *Craspedacusta* in Missouri, with a summary of the American records to date. Amer. Naturalist **66**: 287–288.

1932. Check-list of the birds of Missouri. Univ. Mo. Studies **7**(3): 1–81.

1935. Outlook for wild life in Missouri. Missouri Magazine, March: 21–24.

1936. Game management by state agencies. Trans. No. Amer. Wildlife Conf. **1**: 190–195.

1936. Improving food and cover for wildlife on Missouri farms. I. Trees and shrubs. Univ. Mo. Agric. Ext. Circ. 348: 8 pp. (with R. H. Westveld).

1937. Development and maintenance of food and cover—where and by whom? Trans. No. Amer. Wildlife Conf. **2**: 264–267.

1937. Pocket list of Missouri birds. Audubon Society of Mo. Leaflet #4. 4 pp.

1937. An introduction to bird study in Missouri. Audubon Society of Missouri Bulletin #2 (subsequently published as Bulletin #1, Missouri Conservation Commission). 15 pp.

1937. A survey of the resident game and furbearers of Missouri. Univ. Mo. Studies, **12**(2): 215 pp. (with W. O. Nagel).

1937. Feeding stations and shelters for quail on Missouri farms. Univ. Mo. Agric. Ext. Circ. 356: 8 pp. (with W. O. Nagel).

1938. Wasted energy in wildlife conservation. Amer. Wildlife **27**(1): 14–15, 30.

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1938. Program of wildlife investigation at the state university. Mo. Farm Bureau News, November 30, 1938.

1938. History and uses of the Ashland Area. Mo. Farm Bureau News, December 16, 1938.

1938. Wildlife research—is it a practical and necessary basis for management? Trans. No. Amer. Wildlife Conf. **3**: 48–51.

1939. Wildlife research in Missouri. Mo. Wildlife 1(7): 89, 13–14. (Subsequently published in College Farmer **35**(5): 14.)

1939. Ecology in wildlife management. Outdoor America **4**(3): 4–6, 9.

1939. Reports by quail hunters provide valuable information. Mo. Wildlife **1**(11): 9–10.

1939. Some agricultural characteristics of the Missouri prairie chicken range. Trans. No. Amer. Wildlife Conf. **4**: 491–500.

1939. Badgers in northeastern Missouri and southeastern Iowa. Jour. Mammalogy **20**(3): 373.

1939. Summation of the discussion: Laying the foundations. In Conference on Education in Conservation, symposium at No. Amer. Wildlife Conf., 1939; published as bulletin by National Wildlife Federation: 60–68.

1940. Fundamentals in conservation education. Proc. Mo. Acad. Sci. **5**: 65–70.

1940. Quail hunting. Mo. Wildlife **2**(10): 8.

1940. Geography and wildlife conservation. Jour. Geography **34**(6): 217–225.

1940. Possible temperature factors in north central pheasant distribution. Trans. No. Amer. Wildlife Conf. **5**: 428–432 (with H. V. Terrill).

1941. Research Unit reports on quail survey. Mo. Conservationist **3**(3): 4–6.

1942. The nature and scope of training graduates in wildlife conservation. Trans. No. Amer. Wildlife Conf. **7**: 495–505.

1943. Summer whistling cocks and the fall quail harvest—a relationship? Mo. Conservationist **4**: 1, 12.

1944. Some notes on Missouri quail hunting. Mo. Conservationist **5**(5): 1, 10–11.

1945. Wildlife training at the University of Missouri. Mo. Conservationist **6**(2): 1, 10–11.

1945. Some social factors influencing quail hunting in Missouri, 1938–1944. Jour. Wildl. Mgt. **9**(3): 195–202.

1945. It takes weather as well as birds—. Mo. Conservationist, **6**(5): 2–3.

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1946. University objectives in professional wildlife training. Jour. Wildl. Mgt. **10**(3): 218–227.

1946. Summarization of the Eleventh North American Wildlife Conference. Trans. No. Amer. Wildlife Conf. **11**: 511–518.

1947. Ways and means in wolf-coyote-bobcat control. Part I. Mo. Conservationist **8**(12): 4–6 (with F. W. Sampson).

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1948. The coyote bounty system in Missouri, 1936–1947. Trans. No. Amer. Wildlife Conf. **13**: 314–321.

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1949. Some random thoughts on the Federation. Mo. Wildlife, Jan: 4–5, 12.

1950. Wildlife. Chapter VI in Missouri: its rescurces, people, and institutions. University of Missouri (in press). (with R. S. Campbell).

Some aspects of Missouri quail and quail hunting, 1938–1948. Unpublished.

## CLARENCE STANLEY JOHNSON

### 1894–1949

On August 24, 1949, a Fish and Wildlife Service airplane engaged in control of crop depredations on nearby farmlands crashed on the Lower Souris National Wildlife Refuge, North Dakota, carrying to instant death Clarence S. Johnson, refuge manager, and Roy Ferguson, pilot of the plane. This tragic accident was symbolic of a personal creed which "C.S." had followed throughout his life. He had a deep sense of responsibility for his work and placed that above his personal interests and welfare, and it is possibly because of this that he lost his life at the height of his career. Perhaps, however, this is as "C.S.," as he was known to his many friends, would have wished.

Clarence S. Johnson was born April 7, 1894, in Iron River, Michigan. Much of his early schooling was accomplished at a great personal sacrifice, and a less diligent person would not have endured the many hardships he encountered in attaining a college degree. "C.S." served with credit in the United States Army in the first World War and was discharged as a captain in April, 1919, following which he returned to the University of Wisconsin and was graduated with a Bachelor of Science degree in animal husbandry in 1920. He spent most of his life in the Upper Peninsula of Michigan, a country he dearly loved. Prior to entering the employ of the United States Government as a construction foreman in the Civilian Conservation Corps in 1933, "C.S." had gained a wide range of experience as a railroad sectionhand, trapper, cook, lumberjack and building contractor, in addition to his university training and correspondence studies in mapping and surveying. This provided a useful background for the varied responsibilities as the first refuge manager of the Seney National Wildlife Refuge, Schoolcraft County, Michigan, a position to which "C.S." was appointed in 1936 and retained until June, 1949, when he transferred to the Lower Souris National Wildlife Refuge in North Dakota to fill a job for which he was especially qualified by past training and broad experience in refuge development and practical wildlife management.

His vision, loyalty and faith contributed immeasurably to the enormous undertaking of developing a waterfowl refuge on marginal lands progressively impoverished by logging, fires and drainage. The major development activities were brought to a successful conclusion by 1949. During the intervening years, a series of impoundments were carved out of the wasteland and many hundreds of acres of productive waterfowl habitat developed under his supervision.

Those privileged to tramp over the pine knolls and marshes of Seney with "C.S." and his faithful hunting companion, Duke, and note the quality of waterfowl habitat developed under his direction have been impressed with his ability as a practical wildlife manager. He rightly deserves a large share of the credit for establishing a thriving nesting colony of Canada Geese in a section where this bird was rarely observed as a migrant heretofore. The outstanding results of this undertaking are attested by the increasing numbers of Canada Geese nesting over an expanding range in the Upper Peninsula of Michigan.

Not satisfied with his progress as a practical biologist and wildlife manager, "C.S."

undertook a correspondence course to obtain a greater technical background for the profession he chose to make his life's work. His breadth of vision and ability to see objectives clearly is reflected by his persistent efforts toward the development of waterfowl habitat in an area where many technicians had emphatically stated it could not be done. His record of achievement is attested by the successive increases in wildlife use of wet lands so characteristic in the Lake States Region and all too frequently regarded as unsuited for nesting or the production of significant quantities of natural food. He was among the first to recognize the opportunities for waterfowl management on bog lands, and likewise the important role of beaver in providing waterfowl nesting and feeding grounds.

Under his supervision considerable attention was given to managing stands of northern hardwoods and pine lands for wildlife through selective cutting of merchantable timber. Experiments in controlled burning conducted by "C.S." furnished the necessary background for developing new management techniques in conditioning upland game, as well as waterfowl, habitat characteristic of Seney.

"C.S.'s" striking ability to write with clarity, forcefulness and also humor is known to few, as he found little opportunity to publish on the results of pioneering work in waterfowl management accomplished at Seney thus far. Several papers summarizing projects brought to a successful conclusion during his administration are now in preparation and will be available shortly.

His unflagging interest in conservation was reflected in the planning and execution of his work and readiness to explore new possibilities for realistic means of developing and managing wildlife habitat through water manipulation, controlled burning, timber sales and other promising avenues.

His integrity, deep sense of loyalty and responsibility will long be remembered by his friends and co-workers. His proficiency as a personnel supervisor was outstanding, and his subordinates were imbued with these same high standards possessed by "C.S." A number of Fish and Wildlife Service refuge managers and employees who have advanced to responsible positions obtained their initial training under C. S. Johnson.

The highly successful waterfowl development work on the Seney National Wildlife Refuge will always remain as a fitting tribute to "C.S." and his steadfast faith in the project in the heart of the country he loved so well.

The tragic death of this progressive leader in practical wildlife management is a real loss to the profession, as well as to his family and many friends.—R. E. GRIFFITH

## DONALD G. LAURIDSON

### 1915–1950

On March 23, 1950, Donald Lauridson was killed instantly in a tragic plane accident on the rugged White River plateau near Meeker, Colorado, and almost 70 miles east of the Little Hills Game Experimental Station, his official headquarters.

Under circumstances strangely similar to those that claimed the life of Orange A. Olson in 1945, Donald Lauridson was counting elk in mountainous country when the crash occurred. A downdraft is believed responsible for the accident, in which the pilot, Kenneth Milyard, was painfully but not seriously, injured.

"Butch," as he was known to friends and colleagues, was born November 11, 1915, at Eastlake, Colorado. He graduated from Colorado A & M College in 1939 with a major in forestry and a minor in range management. A few months later he obtained employment with the Colorado Game and Fish Department as a wildlife technician, a connection he held until death, except for military service in 1942–1945.

In May, 1946, "Butch" assumed duties as Superintendent of the Little Hills Game Experiment Station west of Meeker. This property, 15,000 acres in extent and centered around the famous old "Square S" ranch, had just been acquired by the Colorado Game and Fish Department as an ideal location for its big-game and livestock grazing-browsing experiments. Under "Butch" Lauridson's general direction, in which he was strongly

supported by a realistic and forward-looking Game and Fish Department, this pioneer cattle ranch was gradually converted to an experimental area with facilities probably unequalled in the West. It was as the diplomatic, yet efficient, Superintendent of Little Hills that "Butch," inseparable from working cowboy attire, endeared himself to his co-workers; and as the genial, hearty, western host, earned the esteem and good wishes of the hundreds of persons who visited the Station.

Donald Lauridson's military service was with the Corps of Engineers, and for much of the war period he was stationed in Hawaii and the Philippines where he served as a photo interpreter. As such, he participated in an important way in many of the island invasions in the Pacific.

Donald G. Lauridson is survived by his father, John Lauridson, one sister, and four brothers, all of whom reside in or near Eastlake. A younger brother was killed in action in France during the war.—LEE E. YEAGER

# REVIEWS

*Wisconsin Grouse Problems*, by Wallace B. Grange; Wisconsin Conservation Department, Madison 2, Wisconsin; Federal Aid in Wildlife Restoration, No. 5R, Pub. 328, A-1948, pp. 318, numerous plates and figures, bibliography and index. (Actual publication date probably 1949 or 1950; price not specified, but 25¢ to the reviewer and others receiving advance notices.)

The four species of grouse in Wisconsin all thrive at different seres in the development of the climax forest of the region. The way to manage them is to intervene when the favourable stages have passed and start succession over again. Fortunately, the species of grouse succeed each other. A number of agencies, e.g., fire, drainage, clearing, lumbering, pioneer farming, associated with the development of land use from first settlement to the present, have at various times produced bumper crops of pinnated, sharp-tailed and ruffed grouse. At present the land has become generally unsuited for the "prairie" species, but it is still good for ruffed grouse. In time conditions may become poor even for ruffed grouse.

The author states his case with clarity and conviction and supports it with overwhelming evidence. He will surely be known in the future whenever and wherever the production of grouse and the carrying capacity of the land for grouse are considered. In a work received previously, "The Way to Game Abundance," the author seems to have confused the concepts of carrying capacity and population cycle. Here there is no confusion; the cycle appears quite clearly superimposed on the population levels determined by the environment. The latter is seen as vividly as an aerial photograph through a stereoscope. The cover grows and changes under our eyes and the development, optimum, and fade-out for the various grouse is clearly depicted.

Grouse management by controlled burning and by cultivation with a Paul Bunyan type of plough are described. Both seem to have been successful but were not carried through to ultimate conclusions. Even as this review was being drafted the reviewer was compelled to answer a telephone call from an unidentified teacher who had to give a quick reply on some sort of question program to the question "What is the effect of Forest Fire on Wildlife?". An answer which Grange would have approved produced dismay that could be felt over the wire. It is easy to see what his experiments were up against. His evidence is necessarily drawn from the results of natural occurrences, probably classified in the press as calamities.

The question of conflict between grouse management and other land use plans is mentioned and the author simply states his conviction that grouse management is worthwhile and should be given its place in land management. One would expect that once an adequate demonstration has been made, on private land if necessary, public demand will follow. The Wisconsin Department is to be congratulated on bringing out in durable form a report which has permanent as well as immediate reference value.—C. H. D. CLARKE, *Dept. of Lands and Forests, Toronto, Ontario.*

*Sampling Methods for Censuses and Surveys.* By Frank Yates (Head of the Department of Statistics, Rothamsted Experimental Station, Harpenden, Herts, England). London: Charles Griffin & Co., Ltd., 1949. xiv, 318 pp. 24s (New York: Hafner Publishing Co., Ltd. $6.00).

"Sampling Methods for Censuses and Surveys" is an excellent reference for the wildlife research worker or conservation official interested in making a statewide game inventory. The author gives illustrations from his wide experience with agricultural and woodland surveys. Persons in the wildlife profession who wish to apply the fundamental principles of sampling to inventories whether of the mailed questionnaire, personal interview, or physical measurement type should consult this book when planinng the survey in order to conduct the study on a sound statistical basis.

Comprehension of this book requires only experience in handling statistical data, not a background in mathematical statistics. Wildlife technicians lacking even this fundamental experience will find the author's discussion of fundamentals easily understood and enlightening.

The following list of chapter titles illustrates well the scope of this book:

1. The place of sampling in census work.
2. Requirements of a good sample.
3. The structure of various types of samples.
4. Practical problems arising in the planing of a survey.
5. Problems arising in the execution and analysis of a survey.
6. Estimation of the population values.
7. Estimation of the sampling error.
8. Efficiency.

Difficulty in reading may arise as a result of the author's "British" style of writing.—VINCENT SCHULTZ, *Tennessee Game and Fish Comm., Nashville, Tenn.*

*Beaver Management and Ecology in Wyoming.* James E. Grasse and Euvern F. Putnam. Wyoming Game and Fish Commission Bulletin, No. 6, viii+52 pp. Illustrated, 1950. $0.25.

Anyone who is interested in the nation's fur-bearers and especially the beaver will welcome this recent publication of the Wyoming Game and Fish Commission.

The importance of the beaver in the conservation of water and the stabilization of stream flow is emphasized. Some of the relationships of the beaver to other forms of wildlife such as muskrats, mink, big game and waterfowl are pointed out. Beaver-trout relationships are discussed and pictorial evidence presented to support the contention of the authors that the impoundment of water by beaver is most generally beneficial to the propagation of trout in Wyoming.

Chapters V and VI which deal with trapping and transplanting contain a considerable amount of valuable information concerning planting policies, trapping techniques, transplanting techniques, release methods, casualties and miscellaneous observations on transplanted beaver. Through the refinement and use of proper techniques and methods for trapping, handling, holding in pens and transporting the beaver the authors were able to reduce their casualties from 9.8 per cent to 3.0 per cent over a period of three years.

The publication could have been made much more useful if the authors had incorporated more specific or exact data which they have evidently accumulated in their studies of the beaver. The statement is made on page 10 that "Sex ratio among live-trapped beaver (accurate record on 634 animals) is about one male to one female." Biologists in general would have greatly appreciated it if the actual figures or the exact ratio of males to females had been presented. On page 11 the authors state that "We have kept an accurate record of weights and measurements on every beaver we have live-trapped, and could at this point list several graphs and charts showing growth and development." It is unfortunate that this information is not presented.

This publication is profusely illustrated with very good photographs. In fact, the photographs occupy a third of the total page space in the publication. The sketches by Grant O. Hagen are excellently done.—REED W. FAUTIN, *University of Wyoming, Laramie, Wyo.*

# BRIEFER ARTICLES

## NOTES ON POPULATION DYNAMICS OF *MICROTUS* AND *BLARINA* WITH A RECORD OF ALBINISM IN *BLARINA*

The abundance of short-tailed shrews, *Blarina brevicauda brevicauda* (Say), in an area near Syracuse, New York was noted during the course of a small mammal study undertaken from June to September in 1948. The area under investigation, approximately 13 acres in size, was similar to other abandoned farms in this region. A small cattail-filled pond approximately one-tenth of an acre in area was present within the tract. The dominant vegetation of this habitat consisted of orchard grass (*Dactylus glomerata*), timothy (*Phleum pratense*) and thistle (*Cirsium sp.*). A total of 288 small mammals was removed during the three-month period by the use of wooden-based snap traps. The average number of traps used was 60 per night. The genera and quantity of animals caught were as follows: *Blarina*—132, *Microtus*—106, *Zapus*—41, *Peromyscus*—5, *Sorex*—2 and *Mus*—2.

The trapping in the area was continued throughout the investigation. After the first month the animals caught were designated as "drifters." The total population was used as a basis for analysis since it was considered that all species had an equal opportunity to invade the trapped-out habitat. The population of ten shrews per acre surpasses Hamilton's (1931) estimate of a probable four pairs of shrews per acre in choice locality in this region. The field mouse (*Microtus*) population of eight per acre indicates a low in the microtine population and is a marked decline from the previous year's population as determined from early spring "sign." This decline supports Hamilton's (1937b) prediction of a high in 1947–1948 as based on the microtine 4-year cycle for this area. Eadie's (1944) findings stating that a pair of shrews may consume from 14–27 mice per winter appears to be a factor worthy of consideration in computing population densities of mice in restricted areas. This predation may be a contributing factor in the decline of the mice in this area.

The high population of shrews and low population of field mice is reflected in Schueler's (1948) investigation. He recorded a high frequency index for shrews and a low index for mice in the scat of fox collected during the spring, summer and fall of 1947 in a forest habitat of the central Adirondack Mountains near Newcomb, New York. The one year delay in population proportions between the two species from the two regions may be attributed to an environmental factor. The present population of shrews as compared with Blair's (1940) estimate of 2.2 per acre in Michigan indicates a relatively high population, as both habitats are similar.

Among the short-tailed shrews caught was an adult female albino. The animal was trapped in a well-worn runway located approximately fifteen feet from the small pond and five feet from the crest of the pond bank. The vegetation in this moist area was dense and flattened, offering excellent cover. The specimen was completely white except for a few guard hairs over the shoulder region which were flecked with black. The eyes and feet were pink. It was in excellent physical condition and was comparable in size to the three specimens caught from the same runway and to the others taken during this study. The measurements were as follows: General: weight—16.2 gms., total length—107 mm., left hind foot—14 mm., tail—25 mm. The Skull: total length (condylobasal)—23.3 mm., cranial (post zygomatic) width—7.3 mm., interorbital width—6.2 mm., cranial (brain case) length—10.3 mm., condylopostalveolar length—13.7 mm., condyloalveolar length—19 mm., and diastema length—8.9 mm.

The recording of this specimen is considered of interest because of the infrequent occurrence of albinism in the genus *Blarina*. The other recorded incidents of albinism are Hamilton's (1937a) account of an adult male short-tailed shrew collected at Ithaca, New York during 1936 and his reference to another caught by a farmer in Bath, New York. Murray (1937) noted an albino taken by a farmer from Delaware County in Indiana and Ulmer (1940a, 1940b) reported two albino short-tailed shrews, one of which was taken from Delaware in 1906 and the other

from Pennsylvania in 1939.—JACOB SHAPIRO. *New York State College of Forestry, Syracuse, N. Y.*

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## REVERSE FALL MIGRATION

During the fall of 1948 there were at various times waterfowl movements from the Lower Souris Refuge that led off in a northerly direction. These flights differed from the ordinary feeding flights in which cases smaller flocks of waterfowl leave the refuge during morning and evening to feed for short periods in nearby grain fields. Instead, these flights, after leaving the refuge vicinity apparently continued on further north with no immediate return.

On October 10, 1948, M. C. Hammond, L. J. Harrison, T. W. Lawson, and the writer noted an unusually large northwesterly movement of refuge waterfowl beginning at 4:30 p.m. White-fronted geese were first observed flying, but soon afterwards mallards made up the bulk of the flight. This massed flight was principally above the marshes of the Souris River valley but began at places to extend over surrounding grain fields in a more northerly direction. The movement lasted until 6:00 p.m., or later and involved an estimated 50,000 to 100,000 birds. Refuge personnel followed the birds within 12 miles of the Canadian border and reports were later received that hunters had seen them still moving northwest into Manitoba. There were also reports of a heavy morning flight on the same date which apparently moved into Canada.

In order to determine the magnitude and dispersal of waterfowl involved in the fall northward movements, Manitoba mallard returns for banded birds shot the same fall were plotted on the attached overlay.

Only those returns shot during the Manitoba shooting season the same fall as banded are considered for this report. Of the 1948 returns to date (March 13) the most distant northerly return was received from the vicinity of Lake Dauphin, a flight distance of approximately 175 miles due north of the Lower Souris Refuge banding station. Two mallards that were banded on the refuge in the fall of 1948 were shot in the vicinity of Shoal Lake, Manitoba, a distance of 120 miles approximately due north of the refuge banding point. Another refuge-banded mallard of a previous year was taken in the vicinity of Pope, Manitoba, a flight distance of approximately 100 miles north of its banding location. The remainder of the 1948 recoveries, 11, were taken in flight distances of 70 miles or less, mostly in a north to northeasterly direction from the refuge banding site. Of these, a rather concentrated group of returns was received from the vicinity of Whitewater Lake where for 1948, 7 returns have been reported.

Even to date the fourteen 1948 returns from Manitoba more than equal 12 returns received from that province in all previous years. During 1948, 1,255 mallards had been banded on the refuge as compared to 6,128 banded in the combined previous years.

In order to compare the kill on 1948 banded mallards in Manitoba and North Dakota a further check was made. Manitoba reported 14 returns while North Dakota, where usually a much larger group of returns is reported, totalled only 13. To show how

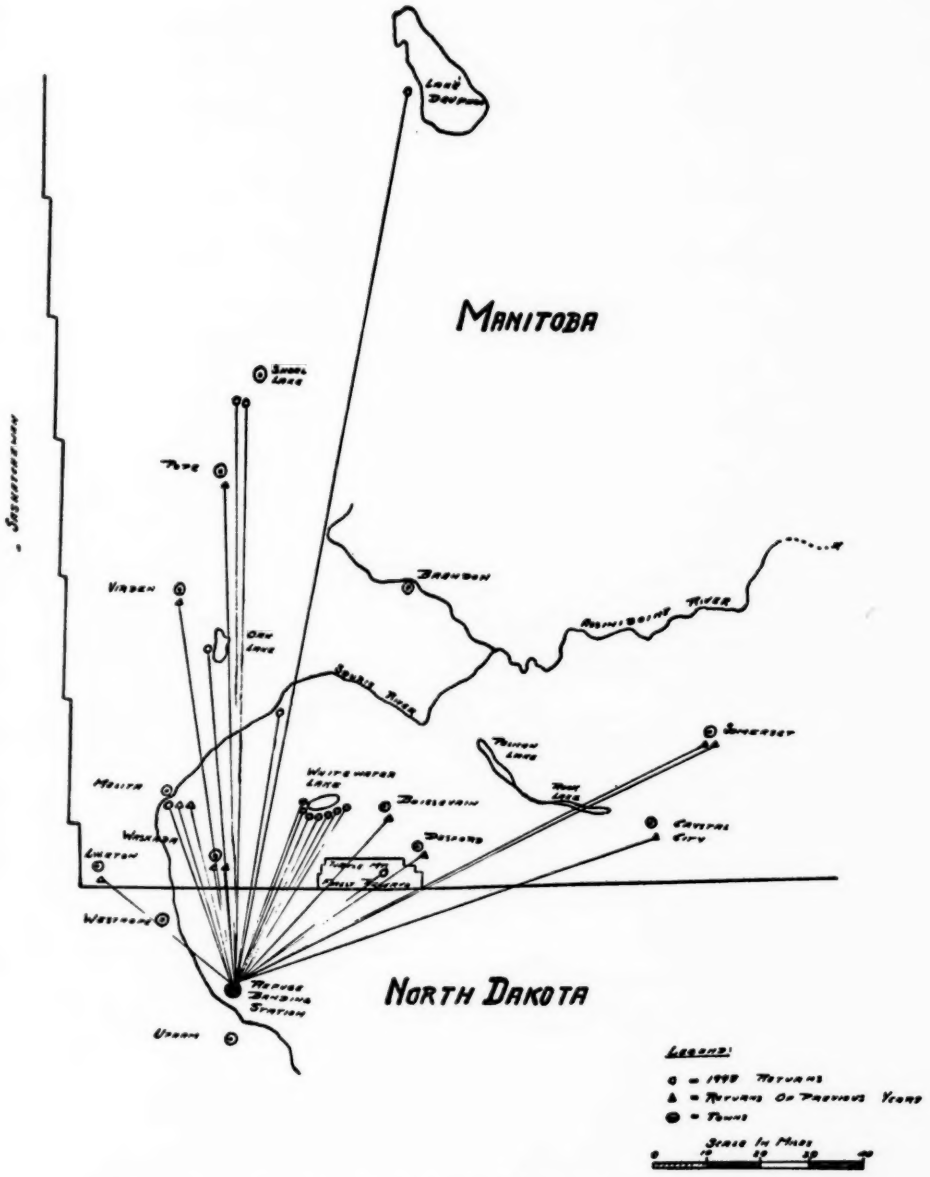


FIG. 1. Lower Souris mallards shot in Manitoba same year as banded.

the distribution more normally occurs, in 1947 three mallard returns were received from Manitoba while North Dakota reported 13; in 1941 no returns were received from Manitoba while North Dakota reported 27. The heavy 1948 Manitoba return indicates that there had been a marked northward withdrawal of birds from the refuge during the fall of 1948.

A comparison was made on sex and age classes of banded mallards against 1948 returns from Manitoba. See Table 1.